

TRAFFIC MANUAL

CHAPTER 5

TRAFFIC CONTROLS

for

Construction and Maintenance Work Zones

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January, 1996
(Revision 2)

NOTICE

Caltrans publishes Standard Specifications, Standard Special Provisions, Standard Plans, etc., which contain specifications and requirements for traffic control devices, including their use and placement, when performing work on State highways. In some cases those specifications and requirements may vary from, and be more stringent than those shown in this Manual. An example is the standard “T” series Traffic Control Plans, contained in the Standard Plans. Whenever there is a discrepancy between the specifications and requirements contained in this Manual and those contained in the documents noted in the beginning of this paragraph for work on State highways, those documents shall govern.

INTRODUCTION

This Manual of Traffic Controls for Construction and Maintenance Work Zones (Manual) is published by the State of California, Department of Transportation (Caltrans), and is issued to provide the basic standards for uniform types of warning signs, lights, and devices to be placed upon any public highway or street by any person engaged in performing work which interferes with the movement of traffic upon such highway or street, in accordance with Section 21400 of the California Vehicle Code.

This Manual is also Chapter 5 of the Caltrans Traffic Manual (CTM), and is published separately for easy reference.

Per the provisions of Sections 1598 and 1599 of the Construction Safety Orders in Title 8 of the California Code of Regulations, this Manual is incorporated by reference as part of those regulations.

It is the responsibility of the Contractor or Organization performing work on, or adjacent to, a highway to install and maintain such devices which are necessary to provide passage for the traveling public (including pedestrians and bicyclists) through the work, as well as for the safeguard of workers. Before work begins, traffic control plans, when developed for handling traffic through a construction or maintenance project, shall be approved by the Engineer of the public agency or authority having jurisdiction over the highway.

Commonly used traffic control devices, conforming to specifications in the 1996 Manual may continue in use until June, 1998. Thereafter, all such devices shall conform to the provisions of this Manual (1996 Manual, Revision1).

Nothing contained in this Manual shall prevent Caltrans from modifying, changing, or adopting new specifications deemed necessary.

The text and figures shown in the Manual are not legal standards except as they describe a device. Criteria for position, location, and use of traffic control devices is furnished solely for the purpose of guidance and information, and is not a legal standard. Engineering judgment must be used to apply these guidelines and typical applications, or adjust them to fit individual field site conditions.

Other reference material related to construction and maintenance zones can be found in the Caltrans Construction and Maintenance Manuals.

**This Manual may be purchased from the California Department of Transportation,
1900 Royal Oaks Drive, Sacramento, California 95815. Phone (916) 445-3520.**

MEANINGS

“Shall”, “Should”, and “May”

In this document the words “shall”, “should”, and “may” are used to describe specific conditions concerning these devices. To clarify the meanings intended by the use of these words, the following definitions apply:

1. **Shall** - A mandatory condition. Where certain requirements in the design or application of the device are described with the “shall” stipulation, it is mandatory when an installation is made that these requirements be met. Exceptions to these conditions on the State Highway System can be approved on a case by case basis by the Manager, Traffic Operations Program or his representative. Documentation shall be provided.
2. **Should** - An advisory condition. Where the word “should” is used, it is considered to be advisable usage, recommended but not mandatory.
3. **May** - A permissive condition. No requirement for design or application is intended.

Road Users

This Manual uses terms such as “traffic”, “motorists”, “vehicles”, “drivers”, and “road users.” These terms are used interchangeably and all are intended to include operators of motor vehicles, including bicyclists, as well as pedestrians.

COLOR CODE

The following color code establishes general meanings for eight colors in a total of twelve colors that have been identified as being appropriate for use in conveying traffic control information. Central values and tolerance limits for each color are available.*

YELLOW - General Warning
RED - Stop or prohibition
BLUE - Motorist services guidance
GREEN - Indicated movements permitted, direction, guidance
BROWN - Recreational and cultural interest guidance
ORANGE - Construction and maintenance warning
BLACK - Regulation
WHITE - Regulation
PURPLE - Unassigned
STRONG YELLOW GREEN - Unassigned
LIGHT BLUE - Unassigned
CORAL - Unassigned

The four colors for which no meaning has been assigned are being reserved for future applications. The meanings described above are of a general nature. More specific assignments of colors are given in the individual parts of this Manual relating to each class of devices.

(*) Available from the Federal Highway Administration (HTO 20), Washington D.C. 20590

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CHAPTER 5

TRAFFIC CONTROLS FOR CONSTRUCTION AND MAINTENANCE WORK ZONES

General Information 5-01

5-01.1 Introduction

During any time the normal function of a roadway is suspended, temporary traffic control planning must provide for continuity of function (movement of traffic, pedestrians, bicyclists, transit operations, and access to property/utilities). The location where the normal function of the roadway is suspended is defined as the work space. The work space is that portion of the roadway closed to traffic and set aside for workers, equipment, and material. Sometimes there may be several work spaces within the project limits. This can be confusing to drivers because the work spaces may be separated by several miles. Each work space should be signed to inform drivers of what to expect.

Effective temporary traffic control enhances traffic operations and efficiency, regardless of whether street construction, maintenance, utility work, or roadway incidents are taking place in the work space. Effective temporary traffic control must provide for the workers, road users, and pedestrians. At the same time, it must provide for the efficient completion of whatever activity suspended normal use of the roadway.

No one set of signs or other traffic control devices can typically satisfy all conditions for a given project. At the same time, defining detailed standards that would be adequate to cover all applications is simply not practical. This Manual displays several diagrams that depict common applications of standard temporary traffic control devices. The traffic control selected for each situation should be based on type of highway, traffic conditions, duration of operation, physical

constraints, and the nearness of the work space to traffic.

Traffic control plans may be adopted by the authority of a public body or official having jurisdiction for guiding traffic. The plans and devices should follow the principles set forth in this Manual but may deviate from the typical drawings to allow for conditions and requirements of a particular site or jurisdiction as determined by the engineer.

The criteria of this Manual are intended to apply to both rural and urban areas. Rural highways are normally characterized by lower volumes, higher speeds, fewer turning conflicts, and fewer conflicts with pedestrians and bicyclists. Urban street traffic is typically characterized by relatively low speeds, wide ranges in traffic volume, narrower roadway lanes, frequent intersections, significant pedestrian traffic, bicyclists and more roadside obstacles.

It is essential that concern for traffic accidents, worker safety and efficiency of traffic movement form an integral element of every temporary traffic control zone, from planning through completion of work activity. Simultaneously, the control selected must permit efficient maintenance/construction of roadways and roadway appurtenances.

5-01.2 Fundamental Principles

All traffic control devices used on street and highway construction, maintenance, utility, or incident management (temporary traffic control) operations shall conform to the applicable specifications of this Manual.

Special plan preparation and coordination with transit and other highway agencies, police and other emergency units, utilities, schools, railroads, etc. may be needed to receive input and support for advising the motorists of the traffic operation situations.

During temporary traffic control activities, commercial vehicles may need to follow a different route from automobiles because of bridge, weight, clearance, or geometric restrictions. Also, vehicles carrying hazardous materials may need to follow a different route from other vehicles. Truck Route National Network and hazardous cargo signs are included in Chapter 4 of the Caltrans Traffic Manual.

Principles and procedures, which experience has shown to benefit the motorists, bicyclists, pedestrians, and workers in the vicinity of temporary traffic control areas, are included in the following listing. These principles and procedures provide a guiding philosophy, for the practitioner, of good temporary traffic control used in work zones. They do not establish specific standards and warrants (individually addressed in the succeeding sections of this Manual).

- A. Traffic operations in temporary traffic control areas should be an integral and high-priority element of every project from planning through design and construction. Similarly, maintenance and utility work should be planned and conducted with motorists, pedestrians, bicyclists, and workers kept in mind at all times. Formulating specific plans for incident management traffic control is difficult because of the variety of situations that can arise. Nevertheless, plans should be developed in sufficient detail to provide for motorists, pedestrians, bicyclists, workers, and enforcement/emergency personnel and equipment.

1. The basic principles governing the design of permanent roadways and roadsides should also govern the design of temporary traffic control zones. The goal should be to route traffic through such areas using geometrics and traffic control devices comparable to those for normal highway situations.
 2. A traffic control plan, in detail appropriate to the complexity of the work project or incident, should be prepared and understood by all responsible parties before the site is occupied. Any changes in the traffic control plan shall be approved by an engineer.
- B. Traffic movement should be disrupted as little as practicable.
1. Traffic control in work and incident sites should be designed on the assumption that drivers will reduce their speeds only if they clearly perceive a need to do so. Reduced speed zoning should be avoided as much as practical.
 2. Frequent and abrupt changes in geometrics such as lane narrowing, dropped lanes, or main roadway transitions requiring rapid maneuvers should be avoided.
 3. Provisions should be made for operation of work or management vehicles, particularly on high-speed, high-volume roadways.
 4. Roadway occupancy and work completion time should be minimized to reduce exposure to potential conflicts.

5. Pedestrians and bicyclists should be provided with access and passage through, or around, the temporary traffic control zone at all times.
 6. Construction or maintenance work on the roadway should be scheduled during off-peak hours and, if necessary, night work should be considered.
- C. Drivers (including bicyclists) and pedestrians should be guided in a clear and positive manner while approaching and space traversing the temporary traffic control zone.
1. Adequate warning, delineation, and channelization by means of proper pavement marking, signs, or use of other devices that are effective under varying conditions of light and weather should be provided where appropriate to assure the driver and pedestrian have positive guidance before approaching and while passing through the traffic control zone.
 2. Signs, pavement markings, channelizing devices, delineators, and other traffic control devices that are inconsistent with intended travel paths through long-term work spaces should be completely removed (see Section 5-05.7). In short-duration and mobile work spaces where retained permanent devices are inconsistent with intended travel paths, attention should be given to devices that highlight or emphasize the appropriate path.
 3. Flagging procedures, when used, can provide positive guidance to drivers traversing the temporary traffic control zone. Flagging should be employed when all other methods of traffic control are inadequate to warn and direct drivers.
- D. To ensure acceptable levels of operation, routine inspection of traffic control elements should be performed.
1. Only individuals who are trained and/or experienced in the principles of traffic control should be assigned that responsibility at work sites. The most important duty of these individuals is to ensure that all traffic control measures implemented on the project are necessary, conform to the traffic control plan, and are effective in providing for motorists, pedestrians, and workers.
 2. Modification of traffic controls or working conditions may be required to expedite traffic movement and to promote worker safety. It is essential that the individual responsible for traffic control have the authority to control the progress of work on the project with the authority to modify conditions or halt work until applicable or remedial measures are taken.
 3. Temporary traffic control zones should be carefully monitored under varying conditions of traffic volume, light, and weather to ensure that traffic control measures are operating effectively and that all devices used are clearly visible, clean, and in good repair.
 4. When the need arises, an engineering analysis should be made (in cooperation with law enforcement officials) of all

accidents occurring in temporary traffic control zones. Temporary traffic control zones and collision records should be monitored to identify and analyze traffic collisions or conflicts. For example, skid marks or damaged traffic control devices may indicate the need for changes in the traffic control.

5. All traffic control devices should be removed when no longer needed. When work is suspended for short periods, advance warning signs that are no longer appropriate shall be removed, covered, or turned, and other inappropriate devices removed from the work zone so they are not visible to drivers.
- E. The maintenance of temporary traffic control zones requires attention during its life because of the potential increase in conflicts.
1. To accommodate run-off-the-road incidents, disabled vehicles, or emergency situations, it is desirable to provide an unencumbered roadside recovery area.
 2. Channelization of traffic should be accomplished by pavement markings, signs, and/or lightweight channelizing devices that will yield when hit by errant vehicles.
 3. Whenever practical, equipment, workers' private vehicles, materials, and debris should be stored in such a manner as to reduce conflicts with run-off-the-road vehicles.
 4. When pedestrian paths traverse through the temporary traffic control zone, temporary pedestrian facilities should be developed to minimize pedestrian exposure to errant vehicles.
- F. Each person whose actions affect temporary traffic control zone from upper-level management personnel through field personnel should receive training and/or experience appropriate to the job decisions each is required to make. Only those who are trained and/or experienced in traffic control practices, and who have a basic understanding of the principles established by applicable standards and regulations, should supervise the selection, placement, and maintenance of traffic control devices in work and incident management zones.
- G. Maintaining good public relations is necessary. The cooperation of the various news media in publicizing the existence of and reasons for work sites can be of great assistance in keeping the motoring public well informed.

Temporary Traffic Control Elements 5-02

5-02.1 Traffic Control Plans

Traffic Control Plans (TCP's) play a vital role in providing continuity for efficient traffic flow, to the extent interruptions in normal flow are necessary for temporary traffic control operations or other events that must temporarily disrupt normal traffic flow. Important auxiliary provisions that cannot conveniently be specified on project plans can easily be incorporated into Special Provisions within the TCP. Also refer to the Caltrans Highway Design Manual Section 110.6.

A TCP describes traffic controls to be used for facilitating all traffic through a temporary traffic control zone. The plan may range in scope from being very detailed, to merely referencing typical drawings contained in this Manual, standard approved highway agency drawings and manuals, or specific drawings contained in contract documents. The degree of detail in the TCP depends entirely on the complexity of the situation, and TCP's should be prepared by persons knowledgeable about the principles of temporary traffic control and the work activities to be performed.

Traffic control planning requires forethought. Provisions may be incorporated into the project bid documents that enable contractors to develop alternate traffic control plans, which may be used only if the responsible agency finds they are as good as those provided in the plans/specifications. For maintenance and minor utility projects that do not require bidding, forethought must be given to selecting the best traffic control before occupying the temporary traffic control zone. Also, coordination must be made between projects to ensure that duplicate signing is not used and to ensure compatibility of traffic control between adjacent projects.

Modifications of TCP's may be necessary because of changed conditions or determination of even better ways of handling traffic efficiently,

while permitting efficient temporary traffic control activities to progress.

5-02.2 Definitions of Temporary Traffic Control Zone Components

The temporary traffic control zone includes the entire section of roadway between the first advance warning sign through the last traffic control device, where traffic returns to its normal path and conditions. Most temporary traffic control zones can be divided into four areas: the advance warning area, the transition area, the activity area, and the termination area. Figure 5-1 illustrates these four areas.

The four components that constitute a temporary traffic control zone are described in the order that drivers encounter them. They include the following:

A. Advance Warning Area

In the advance warning area, drivers are informed of what to expect. The advance warning may vary from a single sign or flashing lights on a vehicle to a series of signs in advance of the temporary traffic control zone transition area. On freeways and expressways, where driver speed is generally in the higher range (70 km/h or more), signs may be placed from 150 m to 800 m or more before the temporary traffic control zone. The true test of adequacy of sign spacing is to evaluate how much time the driver has to perceive and react to the condition ahead. In this regard, the use of speed, roadway condition, and related driver expectancy must be considered in order to derive a practical sign spacing distance. Effective placement of warning signs for urban and rural locals is as follows:

1. Urban

Warning sign spacings in advance of the transition area usually fall within the range of 1 to 2 times the speed (km/h) in meters, with the high end of the range being used when speeds are relatively high. When two or more advance signs are used on higher-speed streets such as major arterials, the advance warning area should extend a greater distance. (See Table 5-3.)

2. Rural

Rural roadways are characterized by higher speeds. Spacing for the placement of warning signs is longer. Two or more advance warning signs are normally used in these conditions; the advance warning area should extend 300 m or more in open highway conditions. (See Table 5-3.) Advance warning is normally not needed when the activity area is 9 m or greater from the driver's path.

B. Transition Area

When redirection of the driver's normal path is required, traffic must be channelized from the normal path to a new path. This redirection is intended to occur at the beginning of the transition area. In mobile operations, this transition area moves with the work space. Transition areas usually involve strategic use of tapers, which are discussed in more detail in Section 5-02.3.

C. Activity Area

The activity area is an area of roadway where the work takes place. It is composed of the work space and the traffic space, and may contain one or more buffer spaces.

1. Work Space

The work space is that portion of the roadway closed to traffic and set aside for workers, equipment, and material. Work space may be fixed or may move as work progresses. Long-term work spaces are usually delineated by channelizing devices or shielded by barriers to exclude traffic and pedestrians.

2. Traffic Space

The traffic space is the portion of the roadway in which traffic is routed through the activity area.

3. Buffer Space

The buffer space is an optional feature in the activity area that separates traffic flow from the work activity and provides recovery space for an errant vehicle. Neither work activity nor storage of equipment, vehicles, or material should occur in this space. Buffer spaces may be positioned longitudinally and laterally, with respect to the direction of traffic flow.

a. Longitudinal Buffer Space

The longitudinal buffer space may be placed in the initial portion of a closed lane in advance of the work space, as shown in Figure 5-1. When a protection vehicle is placed in advance of the work space, only the space upstream of the vehicle constitutes the buffer space.

The longitudinal buffer space, as depicted in Figure 5-2, should be used where a closed lane separates opposing traffic flows. Typically, it is formed as a traffic island and defined by channelizing devices.

A guide for the length of longitudinal buffer space is shown in Table 5-1. The length may be adjusted to satisfy individual agency needs.

b. Lateral Buffer Space

A lateral buffer space may be used to separate the traffic space from the work space, as shown in Figure 5-1, such as an excavation or pavement drop-off. A lateral buffer space also may be used between two travel lanes, especially those carrying opposing flows. The width of the lateral buffer space should be determined by engineering judgment.

4. Incident Management Vehicle Storage Space

When work occurs on a high-volume, highly congested facility in an urban

area, it is optional to allow space to store emergency vehicles (e.g., tow trucks) to respond quickly to traffic incidents. The storage space is typically provided at the beginning or end of the activity area, or both. An emergency vehicle storage area should not extend into any portion of the buffer space.

D. Termination Area

The termination area is used to return traffic to the normal traffic path. The termination area extends from the downstream end of the work zone to the END ROAD WORK signs (C14), if posted. Conditions may be such that posting of END ROAD WORK signs is not helpful. For example, they should normally not be used if other temporary traffic control zones begin within 1500 m of the end of the work space in rural areas, or about 500 m within urban areas. For normal daytime maintenance operations, the END ROAD WORK sign is optional. See also Section 5-05.2, C3, END CONSTRUCTION/ROAD WORK sign.

5-02.3 Tapers

A common important element of a temporary traffic control zone is a roadway taper. Tapers may be used in both the transition and termination areas. Tapers are created using a series of channelizing devices or pavement markings placed to move traffic out of or into its normal path. Whenever tapers are to be used near interchange ramps, crossroads, curves, or other influencing factors, it may be desirable to adjust the length of tapers. Longer tapers are not necessarily better than shorter tapers (particularly in urban areas characterized by short block lengths, driveways, etc.), because extended tapers tend to encourage

Figure 5-1
Component Parts of a Temporary Traffic Control Zone

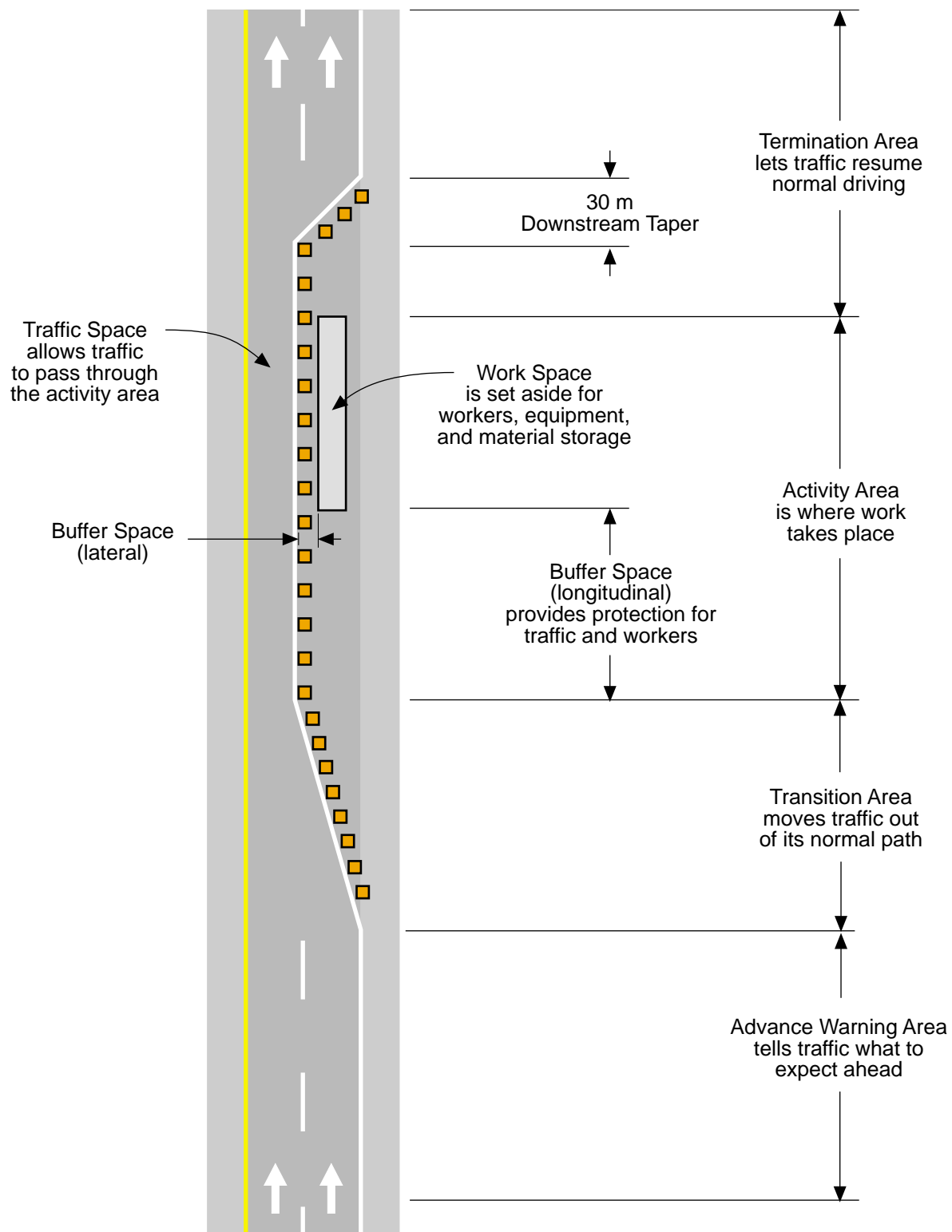


Figure 5-2
Tapers and Buffer Space

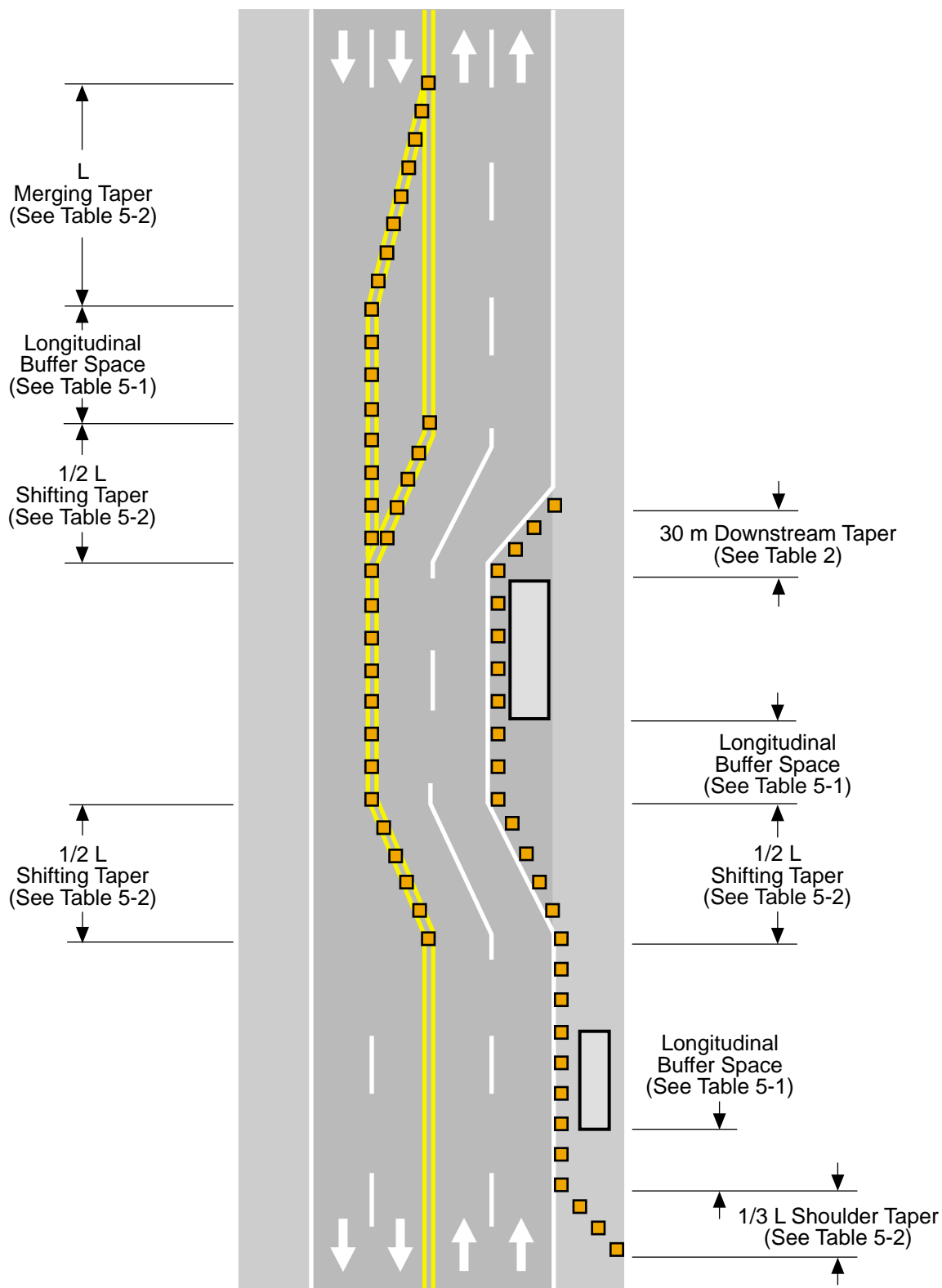


Table 5-1
Guidelines for Length of Longitudinal Buffer Space¹

English Measurements

| Speed in Miles Per Hour* | Length of Buffer Space (feet) |
|--------------------------|-------------------------------|
| 20 | 35 |
| 25 | 55 |
| 30 | 85 |
| 35 | 120 |
| 40 | 170 |
| 45 | 220 |
| 50 | 280 |
| 55 | 335 |
| 60 | 415 |
| 65 | 485 |
| 70 | 585 |

Metric Measurements

| Speed in Kilometers Per Hour* | Length of Buffer Space (meters) |
|-------------------------------|---------------------------------|
| 30 | 10 |
| 40 | 17 |
| 50 | 28 |
| 60 | 43 |
| 70 | 62 |
| 80 | 84 |
| 90 | 106 |
| 100 | 136 |
| 110 | 170 |

*Posted speed, off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.

¹Based upon American Association of State Highway and Transportation Officials (AASHTO) braking distance portion of stopping sight distance for wet and level pavements. This AASHTO document also recommends adjustments for the effect of grade on stopping and variation for trucks.

Table 5-2
Taper Length Criteria for Temporary Traffic Control Zones

Type of Taper

Upstream Tapers
 Merging Taper
 Shifting Taper
 Shoulder Taper
 Two-Way Traffic Taper
 Downstream Tapers
 (Use is optional)

Taper Length

L Minimum
 1/2 L Minimum
 1/3 L Minimum
 30 meters (100 feet) Maximum
 30 meters (100 feet) Minimum

Formula for Taper Length 'L'

(For State Highways, see Traffic Control Systems in the Caltrans Standard Plans.)

English

$L = \frac{WS^2}{60}$ (40 mph or less)
 $L = WS$ (45 mph or greater)
 L = Taper Length in feet
 W = Width of Offset in feet
 S = Speed in mph

Metric*

$L = \frac{WS^2}{150}$ (65 km/h or less)
 $L = \frac{2WS}{3}$ (70 km/h or greater)
 L = Taper Length in meters
 W = Width of Offset in meters
 S = Speed in km/h

S = Posted speed, off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.

* The metric formulas result in larger values due to a rounding off of the constant in converting the English formula to a Metric formula.

sluggish operation and to encourage drivers to delay lane changes unnecessarily. The real test of taper length involves observation of driver performance after traffic control plans are put into effect. Types of taper lengths are presented in Table 5-2. The maximum space in meters between devices in a taper numerically approximates one-fifth the speed in kilometers per hour. Types of tapers are shown in Figure 5-2 and the two-way traffic taper is shown in Figure 5-3:

A. Merging Taper

A merging taper requires the longest distances because drivers are required to merge with an adjacent lane of traffic at the prevailing speed. The taper should be long enough to enable merging drivers to adjust their speeds and merge into a single lane before the end of the transition. For freeways, expressways, and other roadways having a speed of greater than 65 km/h, the minimum length for merging tapers should be computed by a formula $L = 2/3WS$. For residential, urban, and other streets with speeds of 65 km/h or less, the formula $L = (WS^2)/150$ should be used. Under either formula, L is the taper length in meters, W is the lateral shift of traffic due to the partially or fully closed lane (in meters), and S is the posted speed (in km/h), the off-peak 85th percentile speed prior to work starting or the anticipated operating speed. The formula $L = (WS^2)/150$ is used for speeds of 65 km/h or less because slower traffic can merge safely in a shorter distance.

B. Shifting Taper

A shifting taper is used when merging is not required, but a lateral shift is needed. Approximately one-half L has been found

to be adequate. Where more space is available, it may be beneficial to use longer distances. Guidance for changes in alignment may also be accomplished by using horizontal curves designed for normal highway speeds.

C. Shoulder Taper

A shoulder taper may be beneficial on high-speed roadways with improved shoulders that may be mistaken for driving lanes (when work is occurring in, or near, the shoulder area). If used, shoulder tapers approaching the activity area should have a length of about one-third L. If a shoulder is used as a travel lane either through practice or during a temporary traffic activity, a normal merging or shifting taper should be used. An example of a shoulder taper is presented in Figure 5-2.

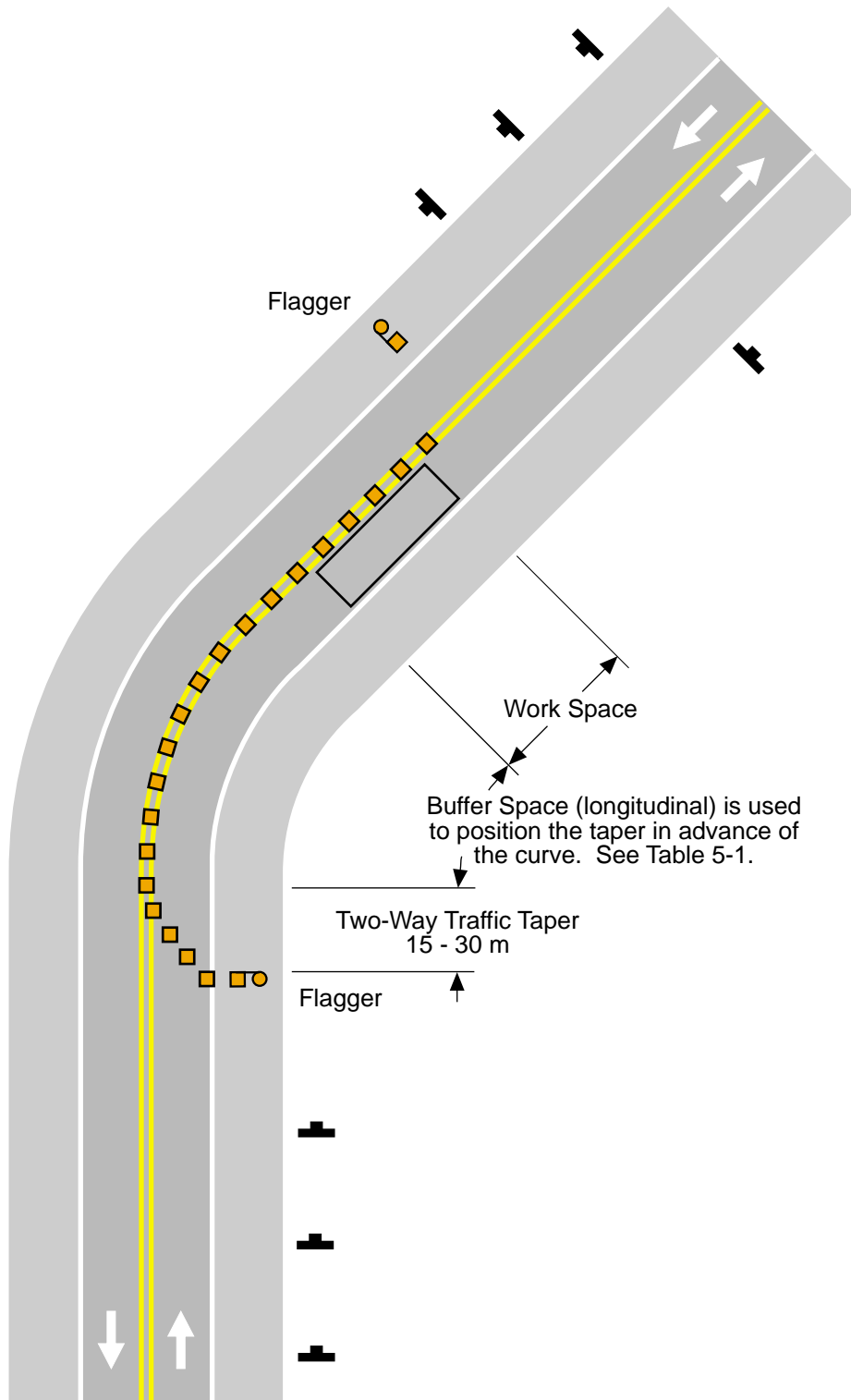
D. Downstream Taper

The downstream taper may be useful in termination areas to provide a visual cue to the driver that access is available to the original lane/path that was closed. When a downstream taper is used, it should have a maximum length of about (Rev. 1)30 meters per lane, with devices spaced about 6 meters apart. An example of a downstream taper is shown in Figure 5-2.

E. One-Lane, Two-Way Taper

The one-lane, two-way traffic taper is used in advance of an activity area that occupies part of a two-way roadway in such a way that a portion of the road is used alternately by traffic in each direction. Typically, traffic is controlled by a temporary traffic signal or a flagger. A short taper having a

Figure 5-3
Example of a Two-Way Traffic Taper



maximum length of 30 m with channelizing devices, or devices normal to centerline at approximately 5 m spacings should be used to guide traffic into the one-way section. An example of a one-lane, two-way traffic taper is presented in Figure 5-3.

5-02.4 Detours and Diversions

At detours, traffic is directed onto another roadway to bypass the temporary traffic control zone. Detours should be signed clearly over their entire length so that motorists can easily determine how to return to the original roadway.

At diversions, traffic is directed onto a temporary roadway or alignment placed in or next to the right-of-way, e.g., median crossovers or lane shifts.

5-02.5 One-Lane, Two-Way Traffic Control

Where traffic in both directions must, for a limited distance, use a single lane, provision should be made for alternate one-way movement through the constricted section. Some means of coordinating movements at each end shall be used to avoid head-on conflicts and to minimize delays. Control points at each end should be chosen to permit easy passing of opposing lines of vehicles. At a "spot" obstruction, however, such as an isolated pavement patch on roadways with lower speeds and adequate sight distance, the movement may be self-regulating.

Alternate one-way traffic control may be accomplished as appropriate by flagger control, a flag-carrying or official car, a pilot car, traffic signals, or by using stop or yield control. This section discusses each of these traffic control techniques. (See Section 5-04.2 for flagger qualifications.)

A. Flagger Method

Where a one-lane two-way temporary traffic control zone is short enough to allow visibility from one end to the other, traffic may be controlled by either a single flagger or by a flagger at each end of the section. When a single flagger is used, the flagger should be stationed on the shoulder opposite the obstruction or work space, or in a position where good visibility and traffic control can be maintained at all times. When good visibility and traffic control cannot be maintained by one flagger station, traffic may be controlled by a flagger at each end of the section. One of the flaggers should be designated as the coordinator. Flaggers should be able to communicate orally or with signals. These signals should not be mistaken for flagging signals. The use of radios may also be desirable even though visual contact is possible.

B. Flag Transfer Method

Flag carrying is effective when the route is well defined. It should be employed only when the one-way traffic is confined to a relatively short length of road, usually not more than 1500 m in length. The driver of the last vehicle proceeding into the one-lane section is given a red flag (or other token) and instructed to deliver it to the flagger at the other end. The opposite flagger, upon receipt of the flag, then knows that it is clear of vehicles coming from that direction and to allow traffic to move in the other direction. The flag being carried should always be clean and dry. A variation of this method is the use of an "official" car that always follows the last vehicle

proceeding through the section. The use of an official car eliminates the possibility of loss of the flag.

C. Pilot Car Method

A pilot car is normally used to guide a queue of vehicles through the more complex temporary traffic control zone or detour. Its operation must be coordinated with flagging operations or other controls at each end of the one-lane section.

The pilot car should have the name of the contractor or contracting authority prominently displayed. The PILOT CAR FOLLOW ME sign (C26) shall be mounted at a conspicuous location on the rear of the vehicle.

Two or more pilot cars may be used to guide two-way traffic through a particularly complex detour.

D. Temporary Traffic Signal Method

Traffic signals may be used to control vehicular traffic movements in temporary traffic control zones. Traffic signals should also be considered for half-width bridge reconstruction on low-to-moderate-volume highways. Typical applications include

highway or street intersections with a temporary haul road or equipment crossing and through areas requiring alternating one-way traffic operations.

E. Stop or Yield Control Method

A yield or stop sign may be installed on low volume, two-lane roads where one side of the roadway is closed and the other side must serve both directions. The side that is closed should yield to or stop for oncoming traffic on the side that is open. The approach to the side that is not closed must be visible (for a distance equal to the safe passing sight distance for that approach) to the driver who must yield or stop. See "No Passing Zones Markings" in Chapter 6 of the Caltrans Traffic Manual.

5-02.6 Transit Considerations

Provision for effective continuity of transit service needs to be incorporated into the temporary traffic control planning process. Often times, public transit buses cannot efficiently be detoured in the same manner as other vehicles (particularly for short-term maintenance projects). On transit routes, the TCP shall provide for features such as temporary bus stops, pull-outs, and waiting areas for transit patrons.

Pedestrian, Bicycle, and Worker Considerations 5-03

5-03.1 Pedestrian Considerations

There are three threshold considerations in planning for pedestrian in temporary traffic control zones on highways and streets:

- Pedestrians should not be led into direct conflicts with work site vehicles, equipment, or operations.
- Pedestrians should not be led into direct conflicts with mainline traffic moving through or around the work site.
- Pedestrians should be provided with a convenient travel path that replicates as nearly as possible the most desirable characteristics of sidewalks or footpaths.

In accommodating the needs of pedestrians at work sites, it should always be remembered that the range of pedestrians that can be expected is very wide, including the visually impaired, the hearing impaired, and those with walking disabilities. All pedestrians need protection from potential injury and a smooth, clearly delineated travel path.

Therefore, every effort should be made to separate pedestrian movement from both work site activity and adjacent traffic. Whenever possible, signing should be used to direct pedestrians to street crossings in advance of an encounter with a temporary traffic control zone. Signs should be placed at intersections so that pedestrians, particularly in high-traffic-volume urban and suburban areas, are not confronted with mid-block work sites that will induce them to skirt the temporary traffic control zone or make a mid-block crossing. It must be recognized that pedestrians will only infrequently retrace their steps to make a crossing. Consequently, ample

advance notification of sidewalk closures is critically important. Refer to Figures TA-28 and TA-29, Section 5-07.3 for typical traffic control device usage and techniques for pedestrian movement through work zones.

When pedestrian movement through or around a work site is necessary, the aim of the engineer should be to provide a separate, footpath without abrupt changes in grade or terrain. Judicious use of special warning and control devices to warn motorists may be helpful for certain difficult work zone situations. These include rumble strips, changeable message signs, hazard identification beacons, flags, and warning lights. Flagger activated audible warning devices may be used to alert pedestrians of the approach of erratic vehicles. Also, whenever it is feasible, closing off the work site from pedestrian intrusions is preferable to channelizing pedestrian traffic along the site solely with temporary traffic control devices such as cones, portable delineators, barricades, or drums. If the possibility of vehicle impact is very low, chain link or other suitable fencing, placed well away from traffic, is acceptable. Solid fencing with plywood, however, can create sight distance restrictions at intersections and at work site access cuts. Care must be taken not to create fenced areas that are vulnerable to splintering or fragmentation by vehicle impacts. Similarly, temporary traffic control devices used to delineate a temporary traffic control zone pedestrian walkway must be lightweight and, when struck, present a minimum threat to pedestrians, workers, and impacting vehicles. Only minimally necessary ballasting with lightweight materials should be used with these devices.

Movement by work vehicles and equipment across designated pedestrian paths should be minimized and, when necessary, should be controlled by flaggers or temporary traffic control. Cuts into work zones across pedestrian walkways

should be kept to a minimum, because they often create unacceptable changes in grade and rough or muddy terrain. Pedestrians cannot be expected to traverse these areas willingly. They will tend to avoid the cuts by attempting non-intersection crossings.

At work sites of significant duration, especially in urban areas with high pedestrian volumes, and where falling debris is a concern (such as work on overhead structures), a canopied walkway is frequently needed to protect pedestrians from falling debris. These covered walkways should be sturdily constructed and adequately lit for nighttime use.

In places where pedestrians are judged especially vulnerable to impact by errant vehicles, all foot traffic should be separated and protected by longitudinal barrier systems. Where a barrier is clearly needed, it should have sufficient strength and low deflection characteristics, to keep vehicles from intruding into the pedestrian space. Further, short, non-continuous segments of longitudinal systems, such as concrete barriers, must be avoided because they nullify the containment and redirective capabilities of the design, increase the potential for serious injury to both vehicle occupants and pedestrians, and encourage the presence of blunt, leading ends. All upstream leading ends that are present shall be appropriately flared or protected with properly installed and maintained impact attenuators. With regard to concrete barriers in particular, it is very important to ensure that adjacent segments are properly joined to effect the overall strength required for the system to perform properly.

It has been determined through study and experience that vertical curbs cannot prevent vehicle intrusions into work zones. As a consequence, normal vertical curbing is not a satisfactory substitute for positive barriers when these are clearly needed. Similarly, contractor-constructed wooden railings, chain-link fencing with horizontal pipe runs, and similar systems

placed directly adjacent to vehicle traffic are not acceptable substitutes for crashworthy positive barriers. In many instances, temporary positive barriers may be necessary to prevent pedestrians from unauthorized movements into the active work zone and to prevent conflicts with traffic by eliminating the possibility of mid-block crossings.

If a high potential exists for vehicle incursions into the pedestrian space, judgment must be exercised as to whether to reroute pedestrians or use barriers. Normally, standard traffic control devices can satisfactorily delineate a temporary traffic control zone pedestrian path, but fail-safe channelization can never be guaranteed with these devices because of the gaps between them. Tape, rope, or plastic chain strung between devices can help discourage pedestrian movements off the designated pathway.

Engineering judgment in each temporary traffic control zone situation should readily determine the extent of pedestrian needs. The engineer in charge of traffic control for temporary traffic control zones should provide both a sense of security and safety for pedestrians walking past work sites and consistent, unambiguous channelization to maintain foot traffic along the desired travel paths.

5-03.2 Bicycle Considerations

There are several considerations in planning for bicyclists in temporary traffic control zones on highways and streets:

- A travel route that replicates the most desirable characteristics of a wide paved shoulder or bikeway through or around the traffic control zone is desirable for bicyclists.
- If the traffic control zone interrupts the continuity of an existing bikeway system, signs directing bicyclists through or around

the zone and back to the bikeway is desirable.

- Unless a separate bike path through or around the traffic control zone is provided, adequate roadway lane width to allow bicyclists and motor vehicles to travel side by side through or around the zone is desirable.
- Bicyclists should not be led into direct conflicts with mainline traffic, work site vehicles, or equipment moving through or around the traffic control zone.

5-03.3 Worker Considerations

Of equal importance to the safety of the public traveling through the temporary traffic control zone is the safety of the worker performing the many varied tasks within the work site. Work zones present temporary and constantly changing conditions that may be unexpected by the traveler. Further, these work zone conditions almost always present situations that are different for the driver. This creates an even higher degree of vulnerability for the personnel on or near the roadway.

Following the Fundamental Principles noted above in Section 5-01.2 will usually provide the degree of control and traffic operation that will bring about the best conditions for the worker. Of particular importance is maintaining work zones with traffic flow inhibited as little as possible, providing standard and clear traffic control devices that get the driver's attention and provide positive direction.

Below are key elements of traffic control management that should be considered in any procedure for assuring worker safety:

- **Training.** All workers should be trained and/or experienced in how to work next to traffic in a way that minimizes their

vulnerability. In addition, workers with specific traffic control responsibilities should be trained and/or experienced in traffic control techniques, device usage, and placement.

- **Worker Clothing.** Workers exposed to traffic should be attired in bright, highly visible clothing similar to that of flaggers. See Section 5-04.3.
- **Barriers.** Barriers should be placed along the work space depending on such factors as lateral clearance of workers from adjacent traffic, speed of traffic, duration of operations, time of day, and volume of traffic.
- **Speed Reduction.** In highly vulnerable situations, consideration should be given to reducing the speed of traffic through regulatory speed zoning, funneling, use of police, lane reduction, or flaggers.
- **Use of Police.** In highly vulnerable work situations, particularly those of relatively short duration, stationing police units heightens the awareness of passing traffic and will likely cause a reduction in travel speed.
- **Lighting.** For nighttime work, lighting the work zone and approaches will allow the driver better comprehension of the requirements being imposed. Care should be taken to ensure that the lighting does not cause blinding.
- **Special Devices.** Judicious use of special warning and control devices may be helpful for certain difficult work zone situations. These include rumble strips, changeable message signs, flashing yellow beacons,

flags, and warning lights. Flagger activated audible warning devices may be used to alert workers to the approach of erratic vehicles. Misuse and overuse of special devices/techniques can greatly lessen their effectiveness.

- **Regulatory Signing.** Usually, the use of regulatory speed zone signing without law enforcement has not shown affective.
- **Public Information.** Improved driver performance may be realized through a well-prepared and complete public relations effort that covers the nature of the work, the time and duration of its execution, its anticipated effects on traffic, and possible alternate routes and modes of travel. Such programs have been found to

result in a significant drop in traffic; that reduces the possible number of conflicts and may allow a temporary lane closing for additional buffer space.

- **Road Closure.** If alternate routes are available to handle detoured traffic, the road may be closed temporarily-which, in addition to offering minimum worker/vehicle conflicts, may facilitate quicker project completion and thus further reduce worker exposure.

Like other provisions of traffic control zone set forth in this Manual, the various traffic control techniques must be applied by qualified persons after appropriate engineering studies and with sound engineering judgment and common sense.

Hand-Signaling Control 5-04

5-04.1 Function

The primary function of traffic control procedures is to move vehicles and pedestrians through or around temporary traffic control zones while protecting on-site workers and equipment.

5-04.2 Qualifications for Flaggers

Because flaggers are responsible for public safety and make the greatest number of public contacts of all highway workers, they should have the following minimum qualifications:

- Sense of responsibility for the public and workers.
- Training and/or experience in traffic control practices.
- Average intelligence.
- Good physical condition, including sight and hearing.
- Mental alertness and the ability to react in an emergency.
- Courteous but firm manner.
- Neat appearance.

5-04.3 High-Visibility Clothing

Flaggers shall wear orange, strong yellow-green, or fluorescent versions of these colored warning garments such as vests, jackets, or shirts. Rainwear, when worn, shall be orange, strong yellow-green, or yellow. During the hours of darkness, flaggers' stations shall be illuminated such that the flagger will be clearly visible to approaching traffic and flaggers shall be outfitted with reflectorized garments. The retroreflective material shall be visible at a minimum distance of 1,000 ft. (304.8) m. The retroreflective clothing, or the retroreflective material added to the clothing, shall have a minimum of one horizontal stripe around the torso. White outer garments with retroreflective material may be worn during hours of darkness in lieu of colored vests, jackets and/or shirts.

Uniformed law enforcement officers may be used as flaggers in some locations, such as an urban intersection, where enforcement of traffic movements is important. Uniformed law enforcement officers may also be used on freeways where traffic is channelled around work sites and it is necessary to assure that advisory and regulatory speeds are being enforced. For nighttime work and in low-visibility situations, a retroreflective garment as described above should be worn.

5-04.4 Hand-Signaling Devices

Hand-signaling devices, such as STOP/SLOW paddles, lights, and red flags are used to control traffic through temporary traffic control zones. The STOP/SLOW paddle, which gives drivers more positive guidance than red flags, shall be the primary hand-signaling device. The standard STOP/SLOW sign paddle shall be 450 mm wide and octagonal in shape with letters at least 150 mm high. A rigid handle should be provided. This combination sign should be fabricated from light semirigid material, and shall have an octagonal

shape. The background of the STOP face shall be red with white letters and border. To improve conspicuity, the STOP/SLOW paddles may be modified to incorporate on the STOP face, one or two symmetrically positioned flashing white light(s) on either the side of, or above and below the STOP legend. The light(s) may be activated by a demand switch or on/off switch. The background of the SLOW face shall be orange with black letters and border. When used at night, the STOP/SLOW paddle shall be retroreflectorized in the same manner as signs.

Flags use shall be limited to emergency situations. Flags used for signaling shall be a minimum of 600 mm square, made of a good grade of red material, and securely fastened to a staff about 900 mm long. The free edge should be weighted so the flag will hang vertically, even in heavy winds. When used at night, flags shall be retroreflective red.

5-04.5 Hand-Signaling Procedures

STOP/SLOW paddle and flag use are illustrated in Figure 5-4. The following methods of signaling with STOP/SLOW paddles should be used:

- **To Stop Traffic.** The flagger shall face traffic and extend the STOP sign paddle in a stationary position with the arm extended horizontally away from the body. The free arm should be raised with the palm toward approaching traffic.
- **To Direct Stopped Traffic to Proceed** The flagger shall face traffic with the SLOW paddle held in a stationary position with the arm extended horizontally away from the body. The flagger should motion with the free hand for traffic to proceed.
- **To Alert or Slow Traffic.** The flagger shall face traffic with the SLOW sign paddle

held in a stationary position with the arm extended horizontally away from the body. The flagger may motion up and down with the free hand, palm down, indicating that the vehicle should slow down.

The following methods of signaling with a flag should be used:

- ***To Stop Traffic.*** The flagger shall face traffic and extend the flag staff horizontally across the traffic lane in a stationary position, so that the full area of the flag is visible hanging below the staff. The free arm should be raised with the palm toward approaching traffic.
- ***To Direct Stopped Traffic to Proceed.*** The flagger shall face traffic with the flag and arm lowered from view of the driver. With the free hand, the flagger should motion traffic to proceed. Flags shall not be used to signal traffic to proceed.
- ***To Alert or Slow Traffic.*** The flagger shall face traffic and slowly wave the flag in a sweeping motion of the extended arm from shoulder level to straight down, without raising the arm above a horizontal position.

5-04.6 Flagger Stations

Flagger stations shall be located far enough ahead of the work space so that approaching traffic has sufficient distance to stop before entering the work space. Table 5-1, Guidelines for Length of Longitudinal Buffer Space, may be used for locating flagger stations in advance of the work space.

This distance is related to approach speeds, friction factors, and pavement and tire conditions. These distances may be increased for downgrades.¹

The flagger should stand either on the shoulder adjacent to the traffic being controlled or in the barricaded lane. At a “spot” obstruction, a position may have to be taken on the shoulder opposite the barricaded section to operate effectively. A flagger should stand only in the lane being used by moving traffic after traffic has stopped, and the flagger needs to be visible to other traffic or to communicate with drivers. Because of the various roadway geometrics, flaggers should be clearly visible to approaching traffic at all times. For this reason the flagger should stand alone.

Other workers should not be permitted to congregate around the flagger station. The flagger should be stationed far enough ahead of the work force to warn them (for example with horns, whistles etc.) of approaching danger, such as vehicles out of control.

Flagger stations should be visible far enough ahead to permit all vehicles to stop. Table 5-1, Guidelines for Length of Longitudinal Buffer Space, may be used in selecting the location of flaggers. This distance is related to approach speeds, friction factors, and pavement and tire conditions. These distances may be increased for downgrades.¹ These distances are calculated in a manner similar to those calculated in the first paragraph of 5-04.6. Flagger stations should be preceded by proper advance warning signs. Under certain geometric and traffic situations, more than one flagger station may be required for each direction of traffic.

During hours of darkness, flagger stations shall be illuminated such that the flagger will be clearly visible to approaching traffic. Lights for illuminating the station shall be approved by the Engineer of the public agency or authority having jurisdiction over the highway. At two-way, unusually low-volume and/or unusually low-speed short lane closings where adequate sight distance is available for the safe handling of traffic, the use of one flagger may be sufficient.

¹ Table III-2. A Policy on Geometric Design of Highways and Streets, AASHTO, 1990, p.125.

Figure 5-4
Use of Hand-Signaling Devices by Flaggers

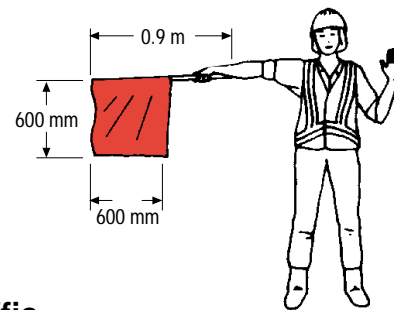
PREFERRED METHOD

Paddle

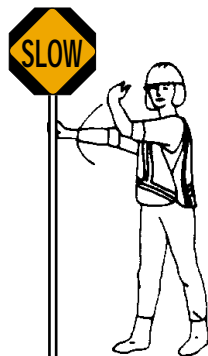


EMERGENCY USE ONLY

Flag



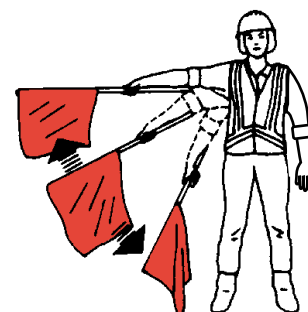
To Stop Traffic



Traffic Proceed



**To Alert and
Slow Traffic**



Types of Traffic Control Devices 5-05

5-05.1 Design and Applications

The design and applications of traffic control devices used in temporary traffic control zones are described in this Manual. A traffic control device is a sign, signal, marking or other device placed on or adjacent to a street or highway (by authority of a public body or official having jurisdiction) to regulate, warn, or guide traffic. Specific crashworthy information on devices described in this chapter can be found in the AASHTO Roadside Design Guide.¹

Where the color orange is specified, fluorescent red-orange or fluorescent yellow-orange colors may be used. The fluorescent versions of orange provide higher conspicuity than standard orange, especially during twilight.

5-05.2 Signs

Temporary traffic control zone signs convey both general and specific messages by means of words or symbols and have the same three categories as all traffic signs: namely, regulatory signs, warning signs, and guide signs. Regulatory signs shall have a black legend on a white background. Warning signs in temporary traffic control zones shall have a black legend on an orange background. Existing yellow warning signs within the traffic control zone which are still applicable may remain in place. Guide signs shall have a white legend on a green background, except for special information signs as noted below in Section 5-05.2C.

All signs used at night shall be either retroreflective, with a material that has a smooth, sealed outer surface, or illuminated to show similar

shape and color both day and night. Sign illumination may be either internal or external. Roadway lighting does not meet the requirements for sign illumination.

Standard orange flags, flashing yellow beacons, or Type B high-intensity flashing warning lights may be used in conjunction with signs. However, they must not block the sign legend.

The dimensions of signs shown herein are for standard sizes, which may be increased wherever necessary for greater legibility or emphasis. On secondary highways and city streets, smaller signs may be used if authorized by lawful authority. Deviations from standard sizes as prescribed herein shall be in 150 mm increments. Sign design details are contained in the Caltrans Traffic Sign Specifications.²

Special signs may be needed based on an engineering analysis. They should conform to the standards for color, shape, and alphabet size and series. The sign message should be brief, legible, and clear.

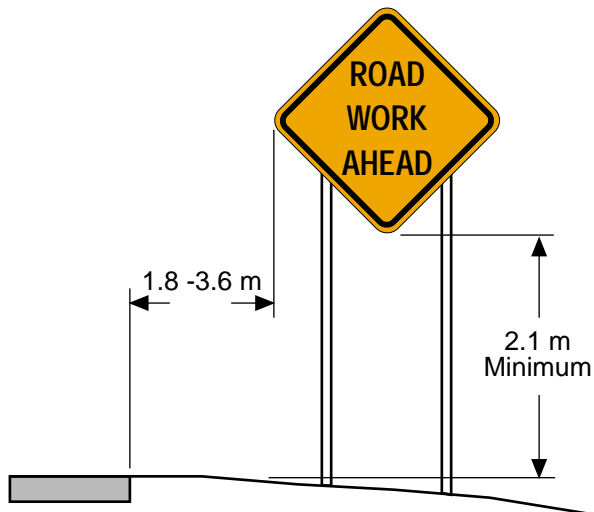
As a general rule, signs should be located on the right-hand side of the roadway. When special emphasis is needed, signs may be placed on both the left and right sides of the roadway. Signs may be mounted on portable supports placed within the roadway itself. Signs, although ordinarily mounted on posts, may also be mounted on or above barricades.

Guidelines for height and lateral clearance of temporary post-mounted roadside signs are shown in Figure 5-5. Signs erected at the side of the road should be mounted at a height of at least 2.1 m, measured from the bottom of the sign to the near edge of the pavement. The height to the bottom of

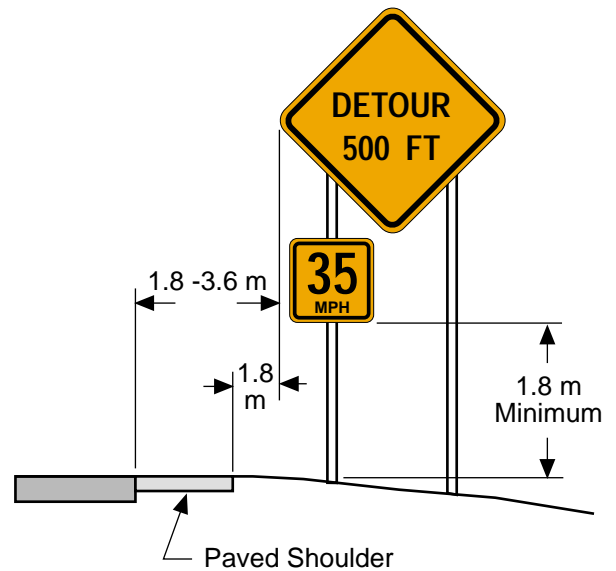
¹ AASHTO, 44 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

² Traffic Sign Specifications are available from the California Department of Transportation Publications Distribution Unit, 1900 Royal Oaks Drive, Sacramento, CA 95815. Telephone (916) 445-3520.

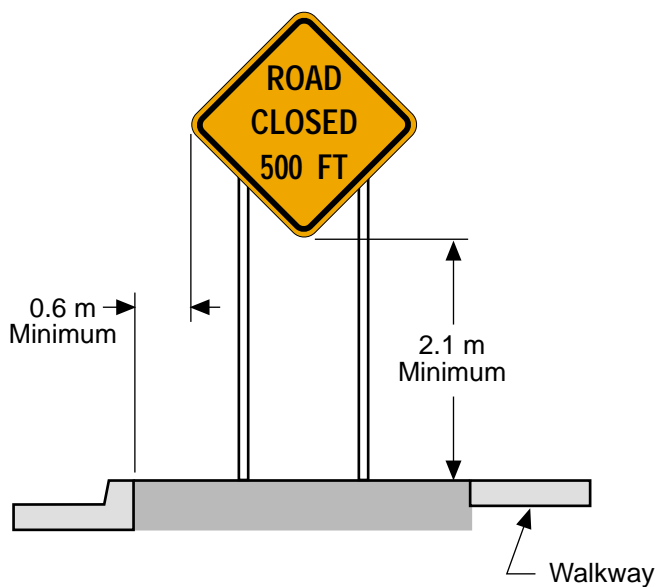
Figure 5-5
Height and Lateral Location of Signs
(Typical Installation)



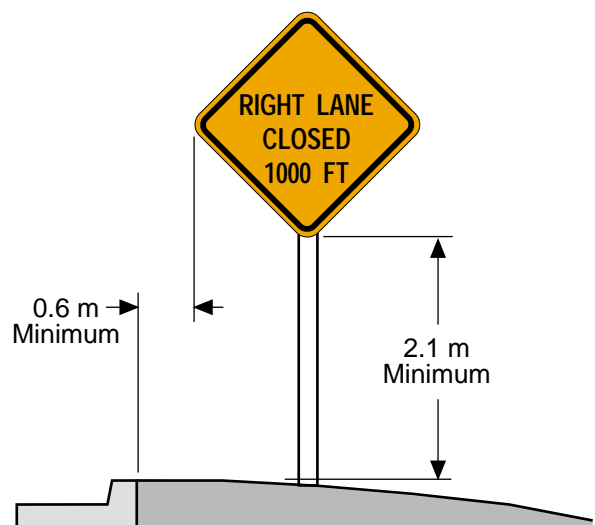
RURAL DISTRICT



**RURAL DISTRICT WITH
ADVISORY SPEED PLATE**



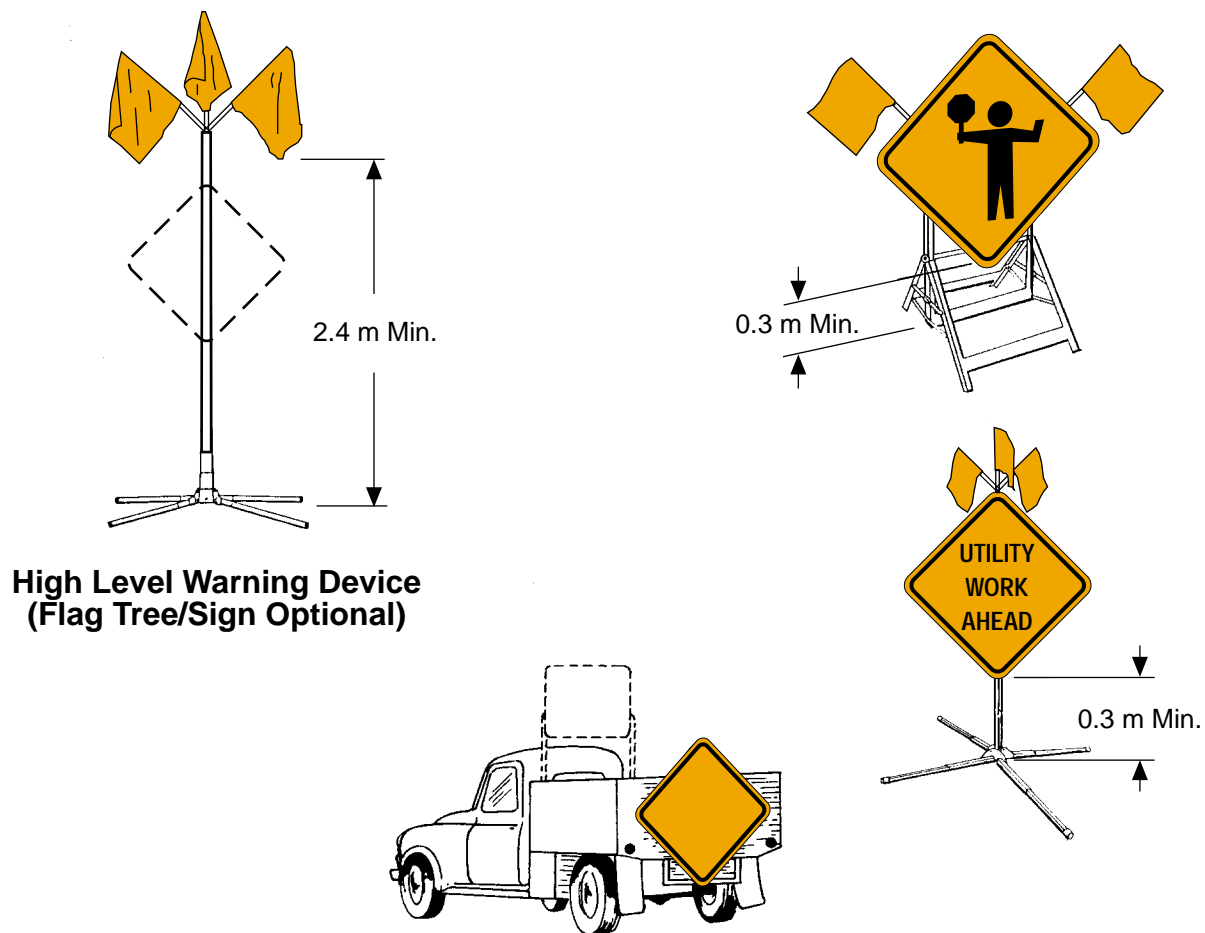
URBAN DISTRICT



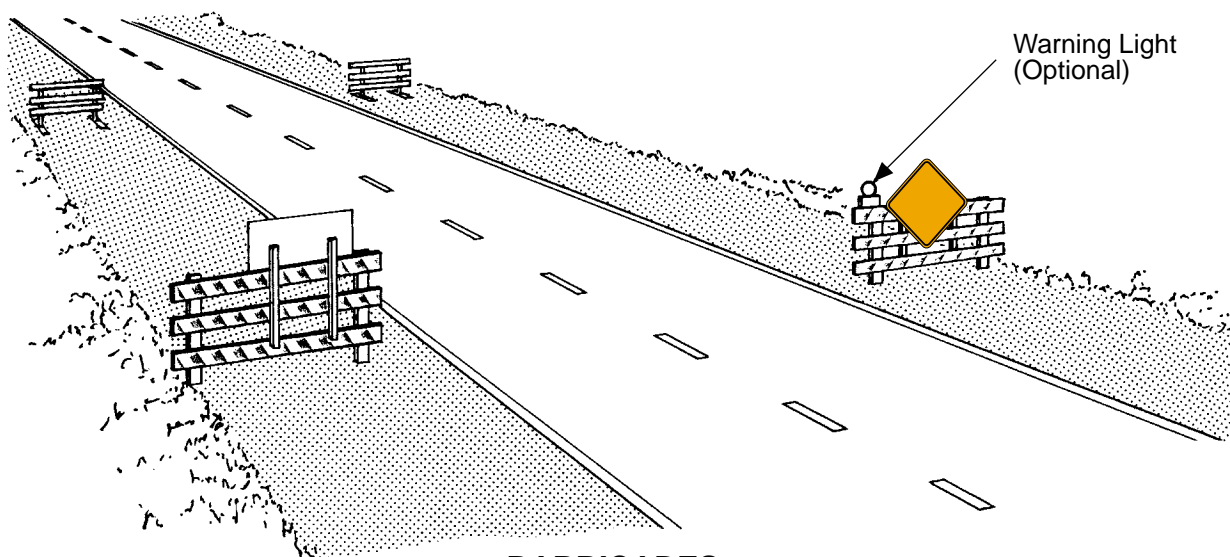
URBAN DISTRICT

1-1996
(Rev. 1)

Figure 5-6
Methods of Mounting Signs Other Than on Posts



PORTABLE AND TEMPORARY MOUNTINGS



BARRICADES

a secondary sign mounted below another sign may be 300 mm less than the appropriate height specified above.

Methods of mounting signs other than on posts are illustrated in Figure 5-6. Signs may be mounted on portable supports for short-term, short-duration, and mobile conditions (see Section 5-06.2). Signs mounted on Type III barricades should not cover more than 50 percent of the top two rails or 33 percent of the total area of the three rails. Unprotected sign systems should be crashworthy. The bottom of signs mounted on barricades or temporary supports shall be no less than 300 mm above the traveled way.

For the best mobility of maintenance operations, a large sign may be mounted on a maintenance vehicle stationed in advance of the work or moving along with it. This may be either the work vehicle or the protection vehicle. A mobile sign display may be mounted on a trailer.

Signs used in temporary traffic control zones are moved frequently, loaded and unloaded from trucks, and in general receive much harsher treatment than permanent signs. For this reason, particular attention must be given to maintaining signs properly for cleanliness, visibility, and correct positioning. Signs that are excessively worn, scratched, bent, or have lost a significant amount of retroreflectivity should be promptly replaced.

A. Regulatory Signs

1. Authority

Regulatory signs inform highway users of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent. Because regulatory signs impose legal obligations on all drivers, they shall be authorized by the public body or official having jurisdiction.

2. Design

Regulatory signs are generally rectangular, with a black legend and border on a white background. Exceptions include the STOP sign, the YIELD sign, the DO NOT ENTER sign, the WRONG WAY sign, and the one-way arrow sign. The one-way arrow sign may be either a horizontal or vertical rectangular plate. Regulatory signs are illustrated in Figures 5-7a and 5-7b. Design details for all regulatory signs are given in the Caltrans Sign Specifications. (See footnote 2, pg. 22)

3. Application

If temporary traffic control zones require regulatory measures different from those normally in effect, the existing permanent regulatory devices shall be temporarily removed or covered and superseded by the appropriate temporary regulatory signs and shall follow applicable ordinances or statutes of the jurisdiction, as well as comply with the sign design standards of the Caltrans Traffic Manual.

4. ROAD CLOSED Sign (C2)

The ROAD CLOSED sign shall be used where the roadway is closed to all traffic except contractors' equipment or officially authorized vehicles and may be accompanied by appropriate detour signing. The sign should be erected at or near the center of the roadway on or above a Type III barricade that closes the roadway (Section 5-05). The sign should have

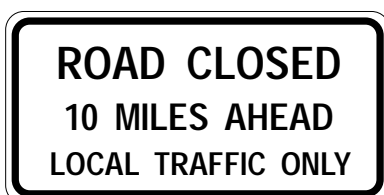
a minimum size of 1200 mm by 750 mm. The words RAMP CLOSED or BRIDGE CLOSED may be substituted for ROAD CLOSED, where applicable. The ROAD CLOSED sign shall not be used where traffic is maintained or where the actual closing is some distance beyond this sign.



C2

5. LOCAL TRAFFIC ONLY Signs (C3, C3A)

The LOCAL TRAFFIC ONLY signs should be used where through traffic must detour to avoid a closing some distance beyond the sign, but where local traffic can move up to point of closure. The sign shall carry the legend ROAD CLOSED [XX] MILES AHEAD-LOCAL TRAFFIC ONLY or, optionally for urban use, ROAD CLOSED TO THRU TRAFFIC, and should be accompanied by appropriate warning and detour signing. The words RAMP CLOSED or BRIDGE CLOSED may be substituted for ROAD CLOSED where applicable.



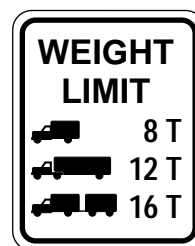
C3



C3A

6. WEIGHT LIMIT Signs (R20, R20B, R20D)

A WEIGHT LIMIT sign shows the gross weight or weight per axle that can be permitted on the roadway or bridge. Weight restrictions should be consistent with state or local regulations and shall not be imposed without the approval of the authority having jurisdiction over the highway. When weight restrictions are imposed, a marked detour should be provided for vehicles weighing more than the limit posted.



R20



R20B



R20D

Figure 5-7a
Commonly Used Regulatory Signs



R1



R1-2



R2



R2-4



R2-5



R3



R15



R16



R17



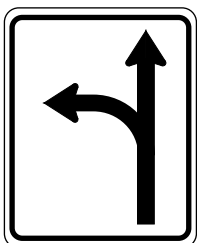
R18-2



R34



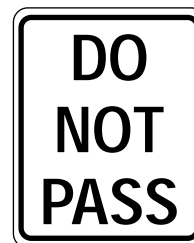
R59



R60A



R61-1.1



R63



R64

Figure 5-7b
Commonly Used Regulatory Signs



R7



R10



R10A



R11



R11A



R26D



R90



SR51



C42

C42
(Alternate Message)

7. Special Regulatory Signs

Special word message regulatory signs may be needed based on an engineering analysis. The sign should conform to the standards for color, shape, and alphabet size and series. The sign message should be brief, legible, and clear.

Regulatory speed limits are established by an engineering analysis which may include a traffic and engineering survey. Chapter 8 of the Caltrans Traffic Manual should be consulted before temporary traffic control zone regulatory speed limits are established. Also, an enhanced enforcement program may need to be considered.

B. Warning Signs

1. Function

Temporary traffic control zone warning signs notify drivers of general or specific conditions on or adjacent to a roadway.

2. Design and Application

With some exceptions, warning signs shall be diamond shaped with a black symbol or message on an orange background. Mounting or space considerations may justify a change from the standard diamond shape, but such variations require prior approval of the highway authority.

Warning signs developed exclusively and used for incident management shall have an orange background. However, in emergencies, available signs having yellow backgrounds may be used if orange signs are not readily available. Sign sizes for various type facilities can be found in the Caltrans Traffic Sign Specifications. (See footnote 2, pg. 22.)

Where any part of the roadway is obstructed or closed, advance warning signs are required to alert traffic well in advance of these obstructions or restrictions. These signs may be used singly or in combination. Because of their importance, they shall have a standard size of 1200 mm square and shall be the standard diamond shape for warning signs, except as provided above. Signs larger than 1200 mm square may be used for additional emphasis of the temporary traffic control zone.

Where speeds and volumes are moderately low, a minimum size of 900 mm square may be used for advance warning signs, if they have a minimum letter size of 125 mm.

On secondary roads or city streets where speeds are very low, signs smaller than the standard size, but not less than 600 mm square, may be used for warning signs having short word messages or clearly understood symbols.

Where distances are not shown on warning signs as part of the message, a separate panel with the distance legend may be mounted immediately below the sign on the same support.

3. Spacing of warning signs is covered in Section 5-07.3 Typical Application Diagrams.

Where highway conditions permit, warning signs should be placed at varying distances in advance of the work zone, depending on the roadway type, condition, and speed. Where a series of two or more warning signs is used, the closest sign to the work zone should be placed approximately 60 m away for low-speed urban streets to 300 m away or more for freeways and expressways.

Table 5-3 presents the suggested spacing of warning signs for four general roadway types for use in Section 5-07.3, Typical Application Diagrams. Actual sign spacing must be tempered by engineering judgement based on site specific conditions.

In Table 5-3, the column headings "A", "B", and "C" are the dimensions for warning sign spacings for use in Section 5-07.3, Typical Application Diagrams. The dimensions are for marking the locations of warning signs relative to the transition or point of restriction.

- The "A" dimension is for the distance from the work zone to the sign nearest the work zone.

- The "B" dimension is for the next sign upstream of the transition or restriction.
- The "C" dimension is for the first sign (in a three-sign series) that the driver encounters in a temporary traffic control zone.

4. Other Approach Warning Signs

Certain conditions require other advance warning signs, such as limited sight distance or because an obstruction may require a motorist to stop. There are no specified standards for such signs. The determination of the sign or signs to be used shall be based on an engineering study using the following sections as guidelines. As an alternative to a specific distance on these advance warning signs, the word AHEAD may be used.

5. Application of Warning Signs for Maintenance, Minor Road Work, and Utility Sites

At many maintenance, minor road work, and utility sites, particularly on lightly traveled roads, the sequence of advance warning signs prescribed for major road work may not be needed. The signs described in the following sections will usually provide sufficient advance warning in such situations, either by themselves or with other advance warning signs.

Maintenance or minor road work can occur within the temporary traffic control zone limits of a major project.

Table 5-3
Suggested Advance Warning Sign Spacing

| Road Type | Distance Between Signs in Meters (Feet) | | |
|--------------------------------|--|------------|------------|
| | A | B | C |
| Urban-40 km/h (25 mph) or less | 60 (200) | 60 (200) | 60 (200) |
| Urban-50 km/h (30 mph) or more | 100 (350) | 100 (350) | 100 (350) |
| Rural | 150 (500) | 150 (500) | 150 (500) |
| Expressway/Freeway | 300 (1000) | 300 (1000) | 300 (1000) |

Note: These are suggested distances for Advance Warning Signs, adequate sight distances and proximity to other roadway features may dictate the need for adjustments when placed.

Maintenance or minor road work warning signs may be needed when traffic is permitted through such zones. Maintenance and minor road work signing and traffic control should be coordinated with appropriate authorities so that drivers are not confused or misled by additional traffic control devices.



C23

6. ROAD CONSTRUCTION/WORK AHEAD Sign (C18/C23)

Either the C18 (CONSTRUCTION) or C23 (WORK) sign should be used in advance of a construction or maintenance project to serve as a general warning of the work zone.

The third line may be altered to read 500 ft., 1000 ft, etc., as appropriate, with a C29 plate.

The C23 sign is also available with the message RAMP WORK AHEAD.



C29

7. DETOUR AHEAD Sign (C1)

The DETOUR AHEAD sign shall be used in advance of a point where traffic is diverted around the work zone over a temporary roadway or route. (See CVC 21363).

The second line may be altered to read 500 ft., 1000 ft, etc., as appropriate.



C1

8. ROAD CLOSED AHEAD Sign (C19)

The ROAD CLOSED AHEAD sign is used in advance of that point where a highway is closed to all traffic or to all but local traffic.

The third line may be altered to read 500 ft., 1000 ft., etc., as appropriate, with a C29 plate

The C19 sign is also available with the message RAMP CLOSED AHEAD.



C19

9. ONE LANE ROAD AHEAD Sign (C16)

The ONE LANE ROAD AHEAD sign should be used ahead of that point where traffic in both directions must use a common single lane. See Figure 5-3. If the affected one-lane roadway is not visible from one end to the other, or if the traffic is such that simultaneous arrivals at both ends occur frequently, flagging procedures or signal control should be used to control alternate traffic flows.

The third line may be altered to read 500 ft., 1000 ft., etc., as appropriate, with a C29 plate.



C16

10. RIGHT LANE CLOSED AHEAD Sign (C20)

The RIGHT LANE CLOSED AHEAD sign is used in advance of the point where one lane of a multiple-lane roadway is closed. A LEFT overlay plate (C20A) is available for left lane closures.

The third line may be altered to read 500 ft., 1000 ft., etc., as appropriate, with a C29 plate.



C20

11. FLAGGER Sign (C9A)

The FLAGGER symbol sign should be used before any point where a flagger is stationed to control traffic. The sign should be used in conjunction with appropriate other warning signs, such as the ROAD WORK AHEAD (C23) and the PREPARE TO STOP (C36).

The flagging sequence signs shall be removed, covered, or turned to face away from traffic when the flagger is not at the station.

The sign may be supplemented with an appropriate distance plate (C29) i.e. 500 ft., 1000 ft., etc., as appropriate.



C9A

12. TWO-WAY TRAFFIC Symbol Sign (W44)

When one direction of travel of a normally divided highway is closed, the TWO-WAY TRAFFIC symbol sign should be used at the beginning of the closing and at intervals to remind drivers that they are on a two-way highway with opposing traffic. The sign should also be used at locations where a divided highway illusion may cause motorists to think they are on a one-way roadway when, in fact, they are on a two-lane, two-way highway.

A typical situation is a construction site where a two-lane highway is being converted to an expressway or freeway and grading for the full width section has been completed.



W44

13. WORKERS Symbol Sign (C22B)

A WORKERS symbol sign may be used to alert drivers of workers in or near the roadway. The sign is normally used on utility type work on conventional low-speed highways. The C22C WORKERS educational plate may be used below the C22B sign.



C22B



C8

14. FRESH OIL Sign (C4)

The FRESH OIL sign should be placed to warn drivers that uncovered road oil or resurfacing has rendered the pavement temporarily slippery, and that splashing may occur.



C4

16. SHOULDER WORK AHEAD Sign (C24)

The SHOULDER WORK AHEAD sign may be used to warn of maintenance, reconstruction, or utility operations on the shoulder, where the traveled way is unobstructed.



C24

15. ROAD MACHINERY AHEAD Sign (C8)

The ROAD MACHINERY AHEAD sign may be used to warn of heavy equipment operating in or next to the roadway.

17. SURVEY CREW Sign (C25)

The SURVEY CREW sign may be used to warn of survey crews working in or next to the roadway.



C25

18. Signs for Blasting Areas

Radio frequency (RF) energy can cause the premature firing of electric detonators (blasting caps) used in temporary traffic control zones or blasting zones. Drivers must be warned to turn off mobile radio transmitters and cellular telephones. The Institute of Makers of Explosives publishes information on this hazard and guidelines for safe operations.¹

A sequence of signs should be used to direct operators of mobile radio equipment to turn off transmitters in a blasting area. A minimum safe distance of 300 m should be used for warning sign placement. These signs shall be predominantly displayed and covered or removed when there are no explosives in the area, or the area is otherwise secured.

¹Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Electric Detonators (Blasting Caps), Safety Library Publication No. 20. Institute of Makers of Explosives, 1120 19th St., N.W. Suite 310, Washington, D.C. 20036-3605. Telephone 202-429-9280.

18a. BLASTING ZONE 1000 FT Sign (C33)

The BLASTING ZONE 1000 FT sign should be used in advance of any work space where explosives are being used. The TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES and END BLASTING ZONE signs shall be used in sequence with this sign.



C33

18b. TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES Sign (C34 Revised)

The TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES sign should follow the BLASTING ZONE AHEAD sign and is placed at least 300 m before the beginning of the blasting zone.



C34

18c. END BLASTING ZONE Sign (C35)

The END BLASTING ZONE sign shall be placed a minimum of 300 m past the blasting zone, either with or preceding the (C14) END ROAD WORK sign.



C35



C41



C41A

19. LOW SHOULDER Sign (C31)

The LOW SHOULDER sign may be used when the elevation between the shoulder and traveled way exceeds 75 mm in height and is not protected by a portable barrier.



C31

21. NO CENTER STRIPE Sign (SC16)
(Not for State Highway use)

The NO CENTER STRIPE sign may be used when the work obliterates the center stripe. This sign should be placed at the beginning of the zone and repeated at 3 km intervals in long zones to remind the motorist. It should also be used at major connections, traffic generators, and/or at appropriate intervals as determined by the engineer, to advise motorists entering within the zone.



SC16

20. UNEVEN LANES Sign (C41 & C41A)

The UNEVEN LANES sign may be used during operations that create a difference in elevation between adjacent lanes.

22. Other Warning Signs

The signs pictured in Figures 5-8a, 5-8b, and 5-8c may also be used to provide sufficient advance warning, either by themselves or with other advance warning signs.

Besides the warning signs specifically related to temporary traffic control zones, several other warning signs, most of which have been standardized in Section 4-02 of the Caltrans Traffic Manual, may apply in these zones. When used in temporary traffic control zones, warning signs shall have a black legend on an orange background except for the W-47 which will always be black on yellow.

23. Advisory Speed Plate (W6)

In combination with a warning sign, an advisory speed plate may be used to indicate a recommended safe speed through the temporary traffic control zone. When used with orange temporary traffic control zone signs, this plate shall have a black legend on an orange background. It shall not be used with any sign other than a warning sign, nor shall it be used alone. The sign shall be at least 600 mm square in size when used with a sign 900 mm square or larger. Except in emergencies, an advisory speed plate (W6) should not be mounted until the recommended speed is determined by the highway authority. See Figures 5-7a and 7b for regulatory signing.



W6

C. Guide Signs

1. Function and Design of Guide Signs

Guide signs are essential along streets and roadways to give drivers information that will help them in the most simple, direct manner possible. The design of guide signs is given in Section 4-04 of the Caltrans Traffic Manual.

The following guide signs are required at temporary traffic control zones:

- a. Standard route markings, where temporary route changes are necessary.
- b. Directional signs such as motorist service signing, recreational and cultural interest area signs, tourist-oriented directional signs (TODS), civil defense signing, and street name signs. When used with detour routing, these signs may have a black legend on an orange background.
- c. Special information signs relating to work being done. These signs shall have a black legend on an orange background.

Figure 5-8a
Warning Signs Used in Temporary Traffic Control Zones



W1



W2



W3



W5



W11



W15



W17



W18



W19



W23



W25



W26



W28



W29



W32



W33

Figure 5-8b
Warning Signs Used in Temporary Traffic Control Zones



W34



W36



W37



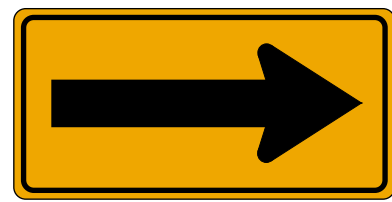
W41



W42



W47



W57



W58



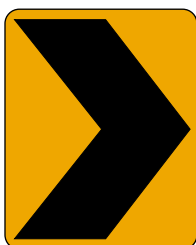
W59



W60



W75



W81



SW40



C6



C36

Figure 5-8c
Warning Signs Used in Temporary Traffic Control Zones



Fed. No. W5-2a*



Fed. No. W9-1*



Fed. No. W14-3*

*Not to be used on State Highways.

2. Length of Work Sign (C11)

The Length of Work sign should be erected in advance of any temporary traffic control zone of more than 3.2 km in length; it carries the legend ROAD WORK NEXT ____ MILES. The distance shall be stated to the nearest whole mile.

The C11 sign is also available with the message STATE HIGHWAY CONSTRUCTION NEXT ____ MILES.



C11

3. END CONSTRUCTION/ROAD WORK Sign (C13, C14)

The END CONSTRUCTION (ROAD WORK) sign should be placed about 150 past the work zone. The sign is not required if the end of the work zone is obvious to motorists.



C14

4. DETOUR Signs and Markers

The DETOUR ARROW sign (C5) should be used where a detour route has been established because of the closing of a street or highway to through traffic. The sign should normally be mounted just below the ROAD CLOSED (C2, C3, or C3A) sign. The DETOUR ARROW sign has a horizontal arrow pointed to the right or left, as required.

Each detour shall be adequately marked with standard temporary route markers and destination signs. The DETOUR marker sign (C5A), mounted at the top of a route marker assembly, marks a temporary route that branches from a highway, bypasses a section closed by a temporary traffic control zone, and rejoins the highway beyond the temporary traffic control zone.

The DETOUR signs (C5, C5A) should be used for detoured highways, for emergency situations, for periods of short durations, or where, over relatively short distances, traffic may be guided along the detour and back to the desired highway. When the detour is a numbered highway, route shields should be included on the sign assembly. A street name sign may be placed above or incorporated in the DETOUR sign to indicate the name of the street being detoured.



C5



C5A

The END DETOUR sign (C7) may be used to indicate that the detour has ended. When the END DETOUR sign is used on a numbered highway, the sign should be mounted above a route shield.



C7

5. PILOT CAR FOLLOW ME Sign (C26)

The PILOT CAR FOLLOW ME sign shall be mounted in a conspicuous position on the rear of a vehicle used for guiding one-way traffic through or around a work space. A flagger shall be stationed at each end of the controlled section of highway. A TRAFFIC CONTROL—WAIT FOR PILOT CAR sign (C37) should be used at intersecting approaches to the pilot car controlled section.



C26

5-05.3 Portable Changeable Message Signs

A. Design

Portable Changeable Message Signs (PCMS) are traffic control devices with the flexibility to display a variety of messages to fit the needs of road and street authorities. Each message consists of one or more displays. Portable Changeable Message signs are used most frequently on high-density, urban freeways, but have applications on all types of highways where highway alignment, traffic routing problems or other pertinent conditions require advance warning and information.

1. Components: The components of a PCMS should include message sign panel, control systems, power source, and mounting and transporting equipment.

- a. Message Sign Panel

PCMS cannot always conform to the exact sign shape, color, and dimensions specified in these standards. PCMS should subscribe to the principles established in the manual, and to the extent practicable, with the design (i.e., color, letter size and shape, and borders) and applications prescribed herein. The message sign panel can vary in size and may consist of one, two, or three lines. High-density urban freeways typically use three lines of eight characters per line. Each character module shall use, as a minimum, a five wide-pixel by seven high-pixel matrix. The front face of the sign should be covered with a protective material. Element colors for warning messages should be black on a yellow or orange background; for guide messages, white on a green background or black on an orange background; and for regulatory messages, black on a white background. Color reversals are also acceptable.

The signs should be visible from 460 m under ideal day and night conditions. Each sign message should be legible from all lanes, from the sign up to a minimum of

230 m. In the field, the PCMS should be sited and aligned to optimize driver perception and understanding. The message panel should have adjustable flash rates, so that the entire message can be read at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.

Under low light level conditions, the sign shall automatically adjust its light source so as to meet the legibility requirements and not impair the drivers' vision.

- b. Control System

The control system shall include the following features:

- A display screen upon which messages can be reviewed before display on the message sign.
- A capability to provide an automatic programmed default message if power failure occurs.
- A backup battery to maintain memory when power is unavailable.

- c. Power Source

The PCMS shall be equipped with a power source and a battery back-up to provide continuing operation when failure of the primary power source occurs.

d. Mounting

The mounting of the PCMS shall be such that the bottom of the message sign panel shall be a minimum of 2.1 m above the roadway when it is in the operating mode.

B. Application.

PCMS have a wide variety of applications in temporary traffic control zones, including roadway or ramp closures, accident or emergency incident management, width restriction information, advisories on roadwork scheduling, traffic management and diversion, warning of adverse conditions, and operation control. PCMS should be used with conventional signs, pavement markings, and lighting.

The primary purpose of PCMS in temporary traffic control zones is to advise the driver of traffic and routing situations. Some typical applications include the following:

- Where speed of traffic is expected to drop substantially
- Where significant queuing and delays are expected
- Where adverse environmental conditions are present
- Where there are severe changes in alignment or surface conditions
- To provide advance notice of ramp, lane, or roadway closures

- For accident or incident management

PCMS should be placed to be visible from at least 450 m under both day and night conditions. Placement in advance of the temporary traffic control zone or incident should, as much as possible, take into account the following factors:

- PCMS will typically be placed in advance of any other temporary traffic control zone signing and should not replace any required signing.
- Where used for route diversion, PCMS should be placed far enough in advance of the work site to allow traffic ample opportunity to exit the affected highway.
- PCMS are normally placed on the shoulder of the roadway. However, if practical, placement further from the traveled lane is desirable.
- When two signs are needed to communicate multiple messages, they should be placed on the same side of the roadway, separated by at least 300 m.

PCMS messages should be readily understood by drivers and thus will allow them adequate time to react. Messages should be designed taking into account the following factors:

- No more than two displays should be used within any message cycle.
- Each display should convey a single thought.
- Messages should be as brief as possible.

- When abbreviations are used, they should be easily understood.
- The entire message cycle should be readable at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.
- Messages shall not scroll horizontally or vertically across the face of the sign.

5-05.4 Flashing Arrow Signs (Arrow Display)

A Flashing Arrow Sign (FAS-arrow display) is a sign with a matrix of elements. The matrix, capable of either flashing or sequential displays, is intended to provide additional warning and directional information to assist in merging and controlling traffic through or around a temporary traffic control zone. An arrow display should be used in combination with appropriate signs, barricades, or other traffic control devices.

A. Flashing Arrow Sign Specifications

FAS shall meet the size and other specifications of Figure 5-9. A PCMS may be used to simulate an arrow display.

Type A arrow displays are appropriate for use on low-speed urban streets. Type II are appropriate for intermediate-speed facilities and for maintenance or mobile operations on high-speed roadways. Type I arrow displays are intended to be used on high-speed, high-volume traffic control projects.

FAS shall be rectangular, of solid appearance, and finished in non-reflective black. The panel shall be mounted on a vehicle, a trailer, or other suitable support.

A vehicle-mounted panel should be provided with remote controls. Minimum mounting height should be 2.1 m from the roadway to the bottom of the panel, except on vehicle-mounted panels, which should be as high as practicable.

FAS shall have the following mode selections:

- A Flashing Arrow, Sequential Arrow, or Sequential Arrowhead (Chevron) mode
- Flashing Double Arrow mode
- Flashing Caution mode

FAS elements shall be capable of a minimum 50 percent dimming from their full-rated lamp voltage. Full lamp voltage should be used for day, and dimmed mode shall be used for night.

FAS shall have suitable elements capable of the various operating modes. If an arrow panel consisting of a bulb matrix is used, the elements should be recess-mounted or equipped with an upper hood of not less than 180 degrees. The color presented by the elements shall be yellow.

Minimum element "on time" shall be 50 percent for the flashing mode and equal intervals of 25 percent for each sequential phase. The flashing rate shall be no fewer than 25 nor more than 40 flashes per minute.

B. Flashing Arrow Sign Application.

A FAS in the arrow or chevron mode may be used for stationary or moving lane closures. The caution mode shall be used

Figure 5-9
Flashing Arrow Sign Specifications

Operating Mode

- I. At least one of the three following modes shall be provided:

Flashing Arrow

Panel Display*
(Right shown; left similar)



Move/Merge Right

Sequential Arrow



Move/Merge Right

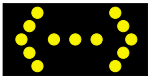
Sequential Chevron



Move/Merge Right

- 2. The following mode shall be provided:

Flashing Double Arrow



Move/Merge Right or Left

- 3. The following mode shall be provided:

Flashing Caution



or



Caution

*Element layout for Type I FAS shown.

| Panel Types | Minimum Size (mm) | Minimum Legibility Distance (km) | Minimum Number of Elements |
|-------------|-------------------|----------------------------------|----------------------------|
| A | 1200 x 600 | 0.8 | 12 |
| II | 1800 x 900 | 1.2 | 13 |
| I | 2400 x 1200 | 1.6 | 15 |

only for shoulder work, blocking the shoulder, roadside work near the shoulder, or work within a closed lane.

For a stationary lane closing, the FAS should be located on the shoulder at the beginning of the taper.

Where the shoulder is narrow, the FAS should be located in the closed lane. If they are used when multiple lanes are closed in tandem, the preferred position for additional arrow displays is in the closed lane at the start of the merge taper. Under various situations, such as for narrow shoulders, placement may be in the middle or at the end of the merge taper but always behind the channelizers. The FAS shall be located behind any channelizing devices used to transition traffic from the closed lane.

For mobile operations where a lane is closed, the FAS arrow display should be located to provide adequate separation from the work operation to allow for appropriate reaction by approaching drivers. A vehicle displaying an arrow display shall be equipped with appropriate signing and/or lighting.

An arrow display shall not be used on a two-lane, two-way roadway for temporary one-lane operation, or within a closed lane.

An arrow display shall not be used to laterally shift, or divert, lanes of traffic because it may cause unnecessary lane changing. For stationary lane closures only one arrow display shall be used for each lane closed; it is normally placed at the beginning of the taper for the closed lane, where traffic must evacuate that lane.

For moving lane closures the arrow display is also used on the advance warning vehicle (in the shoulder area), to reinforce the need for motorists to evacuate the lane(s) closed ahead in which the work vehicles are occupying.

5-05.5 High-Level Warning Devices

The high-level warning device (flag tree) may supplement other traffic control devices in temporary traffic control zones. It is designed to be seen over the top of vehicles. A typical high-level warning device is shown in Figure 5-6.

A high-level warning device shall consist of a minimum of two flags with or without a Type B, high-intensity, flashing warning light. The distance from the roadway to the bottom of the lens of the light and to the lowest point of the flag material shall be no less than 2.4 m. The flags shall be 400 mm square or larger and shall be orange or fluorescent versions of orange in color. An appropriate warning sign may be mounted below the flags.

High-level warning devices are most commonly used in urban high-density traffic situations to warn motorists of short-term operations.

5-05.6 Channelizing Devices

A. General

The function of channelizing devices is to warn and alert drivers of conditions created by work activities in or near the traveled way, to protect workers in the temporary traffic control zone, and to guide drivers and pedestrians. Channelizing devices include, but are not limited to, cones, portable delineators, drums, barricades, temporary raised islands, and barriers.

Devices used for channelization should provide for smooth and gradual traffic movement from one lane to another, onto a bypass or detour, or to reduce the width of the traveled way. They may also be used to separate traffic from the work space, pavement drop-offs, pedestrian paths, or opposing directions of traffic.

Channelizing devices should be constructed and ballasted to perform in a predictable manner when inadvertently struck by a vehicle. If struck, they should yield or break away, and fragments or other debris from the device should not penetrate the passenger compartment of the vehicle or become a flying object which could strike workers or pedestrians in the immediate area.

Spacing of channelizing devices should not exceed a distance in m equal to $0.2 \times \text{km/h (speed)}$ when used for the taper channelization, and a distance in m of $0.4 \times \text{km/h (speed)}$ when used for tangent channelization.

Warning lights on channelizing devices should be considered in fog or snow areas, severe roadway curvature, and unusually cluttered environments. Flashing warning lights may be placed on channelizing devices used singly or in groups to mark a spot condition. Warning lights on channelizing devices used in a series shall be steady-burn.

The retroreflective material used on channelizing devices shall have a smooth, sealed outer surface.

Channelizing devices are elements in a total system of traffic control devices for use in temporary traffic control zones. These elements shall be preceded by a subsystem of warning devices that are adequate in size, number, and placement for the type of highway on which the work is to take place. Standard designs of channelizing devices are shown in Figure 5-10.

The name and telephone number of the agency, contractor, or supplier may be shown on the non-retroreflective surface of all channelizing devices. The letters and numbers shall be a non-retroreflective color and not over 50 mm in height.

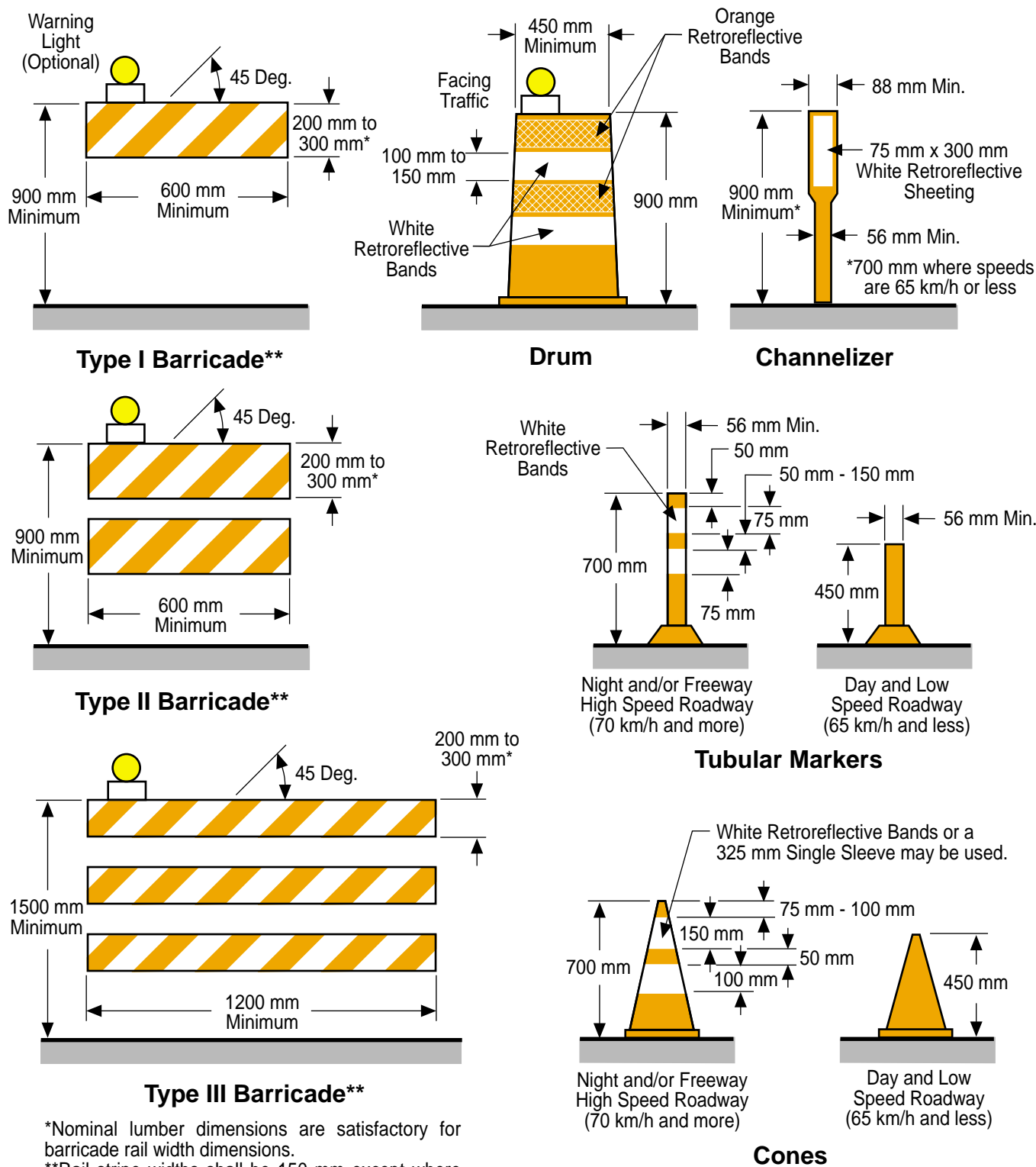
Particular attention should be given to assuring that channelizing devices are maintained and kept clean, visible, and properly positioned at all times. Devices shall be replaced that are damaged and have lost a significant amount of their retroreflectivity and effectiveness.

B. Cones

1. Design

Cones shall be predominantly orange, fluorescent red-orange, or fluorescent yellow-orange, not less than 450 mm in height, and shall be made of a material that can be struck without damaging vehicles on impact. Cones shall be a minimum of 700 mm in height when they are used on freeways and other high-speed highways, on all highways during nighttime, and all State highways, or whenever more conspicuous guidance is needed.

Figure 5-10
Barricades and Channelizing Devices



For nighttime use, cones shall be retroreflective or equipped with lighting devices for maximum visibility. Retroreflection of 700 mm or larger cones shall be provided by a 325 mm band (sleeve), or a white band 150 mm wide, no more than 75 to 100 mm from the top of the cone, and an additional 100 mm wide white band a minimum of 50 mm below the 150 mm band.

2. Application

Traffic cones are used to channelize traffic, divide opposing traffic lanes, divide traffic lanes when two or more lanes are kept open in the same direction, and delineate short-duration maintenance and utility work.

Steps should be taken to ensure that cones will not be blown over or displaced by wind or moving traffic. Cones can be doubled up to increase their weight. Some cones are constructed with bases that can be filled with ballast. Others have special weighted bases, or weighted rings that can be dropped over the cones and onto the base to provide added stability. Ballast, however, should not present any safety concerns if the cones are inadvertently struck.

C. Portable Delineators (Tubular Markers)

1. Design

Portable delineators shall be predominantly orange, not less than 450 mm high, minimum 56 mm wide when facing traffic, and made of a

material that can be struck without damaging impacting vehicles. Portable delineators shall be a minimum of 700 mm high when used on freeways and other high-speed highways, on all highways during nighttime, or whenever more conspicuous guidance is needed.

For nighttime use, portable delineators shall be retroreflective. Retroreflection of portable delineators shall be provided by two 75 mm wide white bands placed a maximum of 50 mm from the top, with a maximum of 150 mm between the bands. The bands shall be visible at 300 m at night when illuminated by standard high beam headlights.

2. Application

Portable delineators have less visible area than other devices and should be used only where space restrictions do not allow for the use of other more visible devices. They may be used effectively to divide opposing lanes of traffic, divide traffic lanes when two or more lanes are kept open in the same direction, and delineate edge of pavement dropoff where space limitations do not allow the use of larger devices.

Steps should be taken to assure that portable delineators will not be blown over or displaced by traffic by either affixing them to the pavement with anchor bolts or adhesive, using weighted bases, or weights that can be dropped over the portable delineators and onto the base to provide added stability. Ballast, however, should not

be allowed to present any safety concerns if the delineators are inadvertently struck. If a noncylindrical device is used, and it could be displayed with a width less than the minimum facing traffic, it shall be attached to the pavement to ensure that the width facing traffic meets the minimum requirements.

D. Channelizers (Permanent type, flexible post)

1. Design

Channelizers are implanted in the ground or affixed (i.e. epoxied) to the pavement, and are not susceptible to displacement, and are capable of normally withstanding numerous vehicular impacts. The height shall be 900 mm minimum (700 mm where speeds are 65 km/h or less), the width of the post shall be 56 mm minimum and the color predominantly orange. The 75 mm x 300 mm minimum retroreflective unit shall be white, and shall be visible at 300 m at night when illuminated by standard high beam headlights. (See Chapter 6 of the Caltrans Traffic Manual for other details and requirements.)

2. Application

Channelizers are generally used in series to create a visual fence/barrier, to provide additional guidance and/or restriction to traffic. They also may be used in lieu of cones, portable delineators, or drums, to channelize traffic, divide opposing lanes of traffic, etc.

E. Drums

1. Design

Drums used for traffic warning or channelization shall be constructed of low-density polyethylene material and shall be flexible or collapsible upon impact by a vehicle. They shall be designed to resist overturning by means of a weighted base that will separate from the drum when impacted by a vehicle. The base shall be of sufficient weight to maintain the drum in position and upright. Ballast, if used, shall be either sand or water contained within the base, or an external ring(s) placed over (and around) the drum, resting on the base. The drum base and/or external ballast ring(s) shall not exceed 100 mm in height, and drum rings shall not exceed 950 mm maximum in diameter. Steel drums shall not be used.

The drum body shall be of a fluorescent orange or predominately orange color. Drums shall be a minimum of 900 mm in height above the traveled way- and have at least a 450 mm minimum width throughout the 900 mm minimum height.

The markings on drums shall be horizontal, circumferential, alternating orange and white retroreflective bands 100 to 150 mm wide. Each drum shall have a minimum of two orange and two white bands. Any non-retro reflectorized spaces between the bands shall not exceed 50 mm wide. The bands shall be visible at 300 m at night when illuminated by standard high beam headlights.

2. Application.

Drums are most commonly used to channelize or delineate traffic flow but may also be used singly or in groups to mark specific locations. Drums are highly visible and have good target value, giving the appearance of being formidable obstacles and, therefore, command the respect of drivers. They are portable enough to be shifted from place to place within a temporary traffic control project to accommodate changing conditions but are generally used in situations where they will remain in place for a prolonged period.

Drums should not be weighted with sand, water, or any material to an extent that would make them a problem for motorists, pedestrians, or workers. When they are used in regions susceptible to freezing, they should have drainage holes in the bottom so water will not accumulate and freeze. Ballast shall not be placed on top of the drum.

F. Barricades.

1. Design.

Barricades are portable or fixed devices having from one to three rails with appropriate markings. They are used to control traffic by closing or restricting all, or a portion, of the right-of-way.

Barricades shall be of three types: Type I, Type II, or Type III.

Stripes on barricade rails shall be alternating orange and white retroreflective stripes sloping downward at an angle of 45 degrees. The stripes shall be 150 mm wide, except where rail lengths are less than 900 mm, then 100 mm wide stripes may be used. The minimum rail length is 600 mm. Barricades used on expressways, freeways, and other high-speed roadways shall have a minimum of 0.17 m² of retroreflective area facing traffic.

Barricade rails should be supported in a manner that will allow them to be seen by motorists and provide a stable support not easily blown over by the wind or traffic. The support for Type I barricades may include other unstriped horizontal panels necessary to provide stability.

Barricades are located adjacent to traffic and, therefore, are subject to impact by errant vehicles. Because of their vulnerable position and the object they become to vehicles, they should be constructed of lightweight materials and have no rigid stay bracing for A-frame designs.

On high-speed highways or in other situations where barricades may be susceptible to overturning in the wind, sandbags should be used for ballasting. Sandbags may be placed on lower parts of the frame or stays to provide the required ballast, but shall not be placed on top of any striped rail. Barricades shall not be ballasted by heavy objects such as rocks or chunks of concrete.

Owner identification shall not be imprinted on the face of any retroreflectorized rail, but may be printed elsewhere.

2. Application

Type I or Type II barricades may be used singly or in groups to mark a specific object. They may also be used as channelizing devices when they are intended to provide additional emphasis in areas where workers are present. Type I barricades normally would be used on conventional roads or urban streets and arterials. Type II barricades have more retroreflective area and are intended for use on expressways and freeways, or other high-speed roadways.

Type III barricades used at a road closure may extend completely across a roadway or from curb to curb. Where provision is made for access of authorized equipment and vehicles, the responsibility for the Type III barricades should be assigned to a person to ensure proper closure at the end of each work day.

When a highway is legally closed but access must still be allowed for local traffic, Type III barricades should not be extended completely across a roadway. A sign with the appropriate legend concerning permissible use by local traffic should be mounted on the barricade(s). (See Section 5-05.2.A.5.)

Signs may be erected on barricades, particularly those of the fixed type.

The ROAD CLOSED and Detour Arrow signs, and the Large Arrow warning signs, for example, can be mounted effectively on or above a Type III barricade(s) that closes the roadway. The bottom of signs mounted on barricades shall be no less than 0.3 m above the traveled way.

G. Portable Barriers

The need for portable barriers should be determined by engineering analysis and the protective requirements of the location, not the channelizing needs. They should be designed in accordance with Caltrans Standard Plans and Specifications.

When serving the additional function of channelizing traffic, the barrier taper shall meet standard channelizing taper lengths. The channelizing barrier shall be supplemented by standard delineators, channelizing devices, or pavement markings. Channelizing barriers should not be used for a merging taper except in low-speed urban areas. See page 5-60 for additional Portable Barriers information and use.

H. Temporary Raised Islands

Temporary raised islands should only be used on roadways with speeds of 70 km/h or less except when recommended by an engineering study.

Temporary raised islands, not to exceed 100 mm in height, may be used to supplement channelizing devices and pavement markings to separate traffic flows in two-lane, two-way operations (TLTWO.) Pavement edge lines may be

placed on the island itself. Islands may also have application in other than TLTWO where physical separation of traffic in the temporary traffic control zone is desired.

One type of temporary raised island is 100 mm high by 450 mm wide and has rounded or chamfered corners. They may be constructed of Portland cement concrete or bituminous concrete.

I. Other Channelizing Devices

Channelizing devices, other than those specified above, may be required for special situations based on an engineering study. Such devices should conform to the general size, color, stripe pattern, retroreflection, and placement characteristics established for standard devices.

5-05.7 Markings

A. Pavement Marking Applications

Adequate pavement markings shall be maintained along paved streets and highways in temporary traffic control zones. Conflicting markings shall be completely removed as identifiable pavement markings under day or night, wet or dry conditions. The work should be planned and staged to provide the best possible conditions for the placement and removal of the pavement markings.

It is intended, to the extent possible, that motorists be provided markings within a work zone comparable to the markings normally maintained along adjacent roadways, particularly at either end of the work zone. The following guidelines set

forth the level of markings and delineation for various work zone situations.

1. All markings shall be in accordance with chapter 6 of the Caltrans Traffic Manual, except as indicated under Section 5-05.7B (Interim Markings) of this manual.
2. Markings shall be maintained in long-term (more than two weeks) stationary work zones and shall match and meet the markings in place at both ends of the work zone.
3. Markings should be provided in short-term (not more than two weeks) stationary work zones, as provided for under Section 5-05.7B (Interim Markings) of this manual.
4. Markings shall be placed along the entire length of any surfaced detour or temporary roadway, before such detour or roadway is opened to traffic.
5. Centerlines and lanelines should be placed, replaced, or delineated where appropriate before the roadway is opened to traffic.
6. In any work zone where it is not practical to provide a clear path by markings, appropriate warning signs, channelizing devices, and delineation shall be used to indicate the required vehicle paths.

All markings and devices used to delineate vehicle and pedestrian paths shall be carefully reviewed during daytime and nighttime periods to assure they lead drivers or pedestrians in the intended path.

Proper pavement marking obliteration leaves a minimum of pavement scars and completely removes old marking materials. Obliterated markings shall be unidentifiable as pavement markings under day or night, wet or dry conditions. Overlaying existing stripes with black paint or asphalt does not meet the requirements of covering, removal, or obliteration; however, the use of removable, nonreflective, preformed tape is permitted where markings need to be covered temporarily.

B. Interim Markings

Delineation in construction and maintenance zones is intended to be a guide to indicate the alignment of the roadway and outlines the required vehicle path through these areas.

Delineators are reflector units capable of clearly reflecting light under normal atmospheric conditions from a distance of 300 m when illuminated by the upper beam of standard automobile lights.

Interim pavement markings are those that may be used until installation of pavement markings that meet the standards for permanent pavement markings. Interim pavement markings, as described below, shall not be left in place for more than two weeks (short term). Interim pavement markings, to remain in place for more than two weeks (long-term), shall conform to the requirements for permanent markings. (See Chapter 6 of the Caltrans Traffic Manual.)

1. Temporary lanelines and/or centerlines shall consist of retroreflectorized lines approximately 600 mm long, 100 mm wide, spaced approximately 7.3 m apart. Day/night raised retroreflectorized pavement markers, approved by the California Department of Transportation (Caltrans), may be used in lieu of 600 mm lines, spaced approximately 7.3 m apart.
2. Right edgelines should not be simulated with dashes or pavement markers because they could confuse motorists; however, portable delineators, permanent type delineators, etc., may be used where it is considered desirable to enhance the edge of traveled way due to curvilinear alignment, narrowing pavement, etc.
3. Locations on two-lane conventional highways where no-passing zone centerline delineation has been obliterated shall be posted with a sign package consisting of a "ROAD CONSTRUCTION/WORK AHEAD" sign(s) C18/C23 and a "DO NOT PASS" sign R63. The R63 sign should be posted at 600 m intervals throughout the extended no-pass zone. A "PASS WITH CARE" sign R64 should also be placed at the end of the zone.

C. Raised Pavement Markers.

Raised pavement markers should be considered for use along surfaced detours or temporary roadways, and other changed or new travel way alignments, because of the need to accentuate changed travel paths and their wet-weather performance capabilities.

Non-retroreflective raised pavement markers, supplemented by retroreflective markers, may be used to simulate painted lines as shown in Chapter 6 of the Caltrans Traffic Manual.

D. Delineators

Delineators (retroreflective units) may be used in work zones to indicate the alignment of the roadway through the temporary traffic control zone. Delineators, when used, shall be used in combination with, or be supplemental to, other traffic control devices.

Delineators shall be mounted on suitable supports about 1.2 meters above the near roadway edge, placed 0.6 to 1.8 m outside the outer edge of the shoulder. They shall be 75 mm x 300 mm minimum and the color shall be the same as the color of the edgeline; white on the right side of traffic, and yellow on the left. Delineators shall be visible at 300 m at night when illuminated by standard high beam headlights. Spacing along roadway tangents and curves should be as set forth in Section 6-04 of the Caltrans Traffic Manual.

5-05.8 Lighting Devices

A. Function

Temporary traffic control activities often create conditions on or near the traveled way that are particularly unexpected at night, when drivers' visibility is sharply reduced. It is often desirable and necessary to supplement retroreflectorized signs, barriers, and channelizing devices with lighting devices.

Four types of lighting devices are commonly used: floodlights, flashing yellow beacons, steady-burning electric lamps, and warning lights.

In work zones where a study indicates a nighttime collision problem can be corrected with area illumination, consideration may be given to providing roadway lighting.

B. Floodlights

In temporary traffic control zones, floodlights have a limited but important application. Temporary traffic control activities on urban freeways must frequently be conducted during nighttime periods when traffic volumes are lower. Sometimes, large temporary traffic control contracts are also operated on double shift, requiring night work. When nighttime work is required for these or similar types of projects, floodlights should be used to illuminate flagger stations, equipment crossings, and other areas where existing light is not adequate for the work to be performed.

In no case shall floodlighting be permitted to create a disabling glare for drivers. The adequacy of the floodlight placement, and elimination of potential glare, can best be determined by driving through and observing the floodlighted area from each direction on the main roadway after initial floodlight setup.

Construction and maintenance activities on urban freeways with high-volume, high-density traffic conditions are frequently conducted during nighttime periods (with

low traffic volumes). Floodlighting of the work site is important because the workers need to see what they are doing, and because the workers and the work space needs to be seen by passing drivers.

C. Portable Flashing Beacons

Portable flashing beacons may be used near points of potential conflict as a means of calling motorists' attention to these locations. When used, they should normally be operated 24 hours a day.

The beacons may be operated singly or in groups. Each flashing beacon unit shall consist of a lighting unit, a flasher unit, a standard, a power source, and a base. Power may be provided by batteries or A.C. electricity. Portable units should be self-contained, which can be delivered to the job site and be placed in immediate operation.

The beacon lens shall have a visible diameter of 300 mm and shall conform to State standards for signal lenses, and the lighting unit shall have a hood and backplate or other suitable means of providing adequate contrast.

The flasher unit shall provide 50 to 60 flashes per minute with 250 to 350 milliseconds dwell time. The lamp shall provide a light output equivalent to a 25 watt incandescent lamp.

The mounting height shall be between 1.8 and 3 m, measured from the bottom of the base to the center of the lens.

During normal daytime maintenance operations, the functions of flashing

beacons are adequately provided by rotating dome or strobe lights on vehicles. However, flashing beacons may be installed at locations where work activities require an obstruction(s) to remain in the roadway at night. (See Section 9-05 "Flashing Beacons" of the Caltrans Traffic Manual.)

D. Steady-Burning Electric Lamps

As used herein, steady-burning electric lamps shall mean a series of low-wattage yellow electric lamps. They may be used to mark obstructions, but they are generally less effective than flashing lights for such use because of their attention-getting effect. However, if lights are needed to delineate the traveled way through and around obstructions in a temporary traffic control zone, the delineation shall be accomplished by steady-burning lamps.

Steady-burning lamps, placed in a line on appropriate channelizing devices, are effective in delineating the proper vehicle path through temporary traffic control zones that require changing patterns of traffic movement. Steady-burning lamps are also used on detours, on lane closures, when the roadway alignment changes in tapers, and other situations where the headlights do not provide retroreflection to delineate the intended vehicle path.

The application of these devices during maintenance work is infrequent due to the generally short-term nature of the work. A type of maintenance activity where steady-burning lamps could be used is removal and replacement of a part of a bridge deck. The lamps could be mounted on barricades and help channel traffic around the work space.

E. Warning Lights

The light weight and portability of warning lights are advantages that make these devices useful as supplements to the retro-reflectorization on hazard warning devices. The flashing lights are effective in attracting a driver's attention.

As used herein, warning lights are portable, lens-directed, enclosed lights. The color of the light emitted shall be yellow. They may be used in either a steady-burn or flashing mode. Warning lights shall be in accordance with the current ITE Purchase Specification for Flashing and Steady-Burn Warning Lights¹.

Warning lights shall have a minimum mounting height of 750 mm to the bottom of the lens. Type A low-intensity flashing warning lights are most commonly mounted on barricades, drums, or advance warning signs, and are intended to warn drivers that they are approaching, or in, an area of potential conflict.

Type B high-intensity flashing warning lights are normally mounted on advance warning signs or on independent supports. Site conditions within temporary traffic control zones may require that the lights be effective in daylight as well as dark. They are designed to operate 24 hours per day. Flashers shall not be used for delineation, as they would tend to obscure the desired vehicle path.

Type C steady-burn lights are intended to be used to delineate the edge of the traveled way on detour curves, on lane changes, on lane closures, and on other similar conditions.

Type A low intensity flashing warning lights and Type C steady-burn warning lights shall be maintained so as to be visible on a clear night from a distance of 900 m. Type B high intensity flashing warning lights shall be maintained so as to be visible on a sunny day, when viewed without the sun directly on or behind the device, from a distance of 300 m.

5-05.9 Other Devices

A. Crash Cushions

Crash cushions (also known as impact energy attenuators) are systems that mitigate the effects of errant vehicles that strike objects, either by decelerating the vehicle to a stop when hit head-on, or by redirecting the errant vehicle. Crash cushions in temporary traffic control zones protect motorists from the exposed ends of barriers, and other fixed objects. Two types of crash cushions used in temporary traffic control zones are roadside crash cushions and truck-mounted crash cushions (TMCC). Information about designs and types of crash cushions currently approved for use on State highways is available from Caltrans' Division of Traffic Operations in Sacramento.

¹Included in the Equipment and Material Standards of the Institute of Transportation Engineers Publication No. ST 017; 525 School Street, S.W., Suite 410, Washington, D.C. 20024. Telephone: 202-554-8050.

Crash cushions must pass acceptable performance testing and be designed to ensure performance to minimize injury to motorists or redirect errant vehicles. Periodic inspection of these devices is necessary to assure that they function as intended throughout their useful life, or that they undergo prompt repair/replacement if hit or damaged.

1. Roadside Crash Cushions

Roadside crash cushions are used in the same manner as permanent highway installations to protect motorists from the exposed ends of barriers, and other fixed objects. Two types of stationary cushions are commonly used and must be designed for the specific application intended as follows:

a. Redirective Type

The redirective type is an assembled unit designed to absorb head-on vehicle impacts and telescope toward the rear; also it may be capable of absorbing side impacts by redirecting a vehicle.

Redirective types normally are used when the exposed object is narrow, or when space for a non-redirective type is unavailable, such as on surface streets near adjacent intersecting roadways. The cushion width must be wider than the object it is shadowing, but as close to the object width as possible, to prevent its lateral intrusion into the traffic lanes.

b. Non-redirective Type

The non-redirective type may be struck head-on, and may be the sand-filled plastic barrel system or other acceptable energy-absorbing device designed to stop errant vehicles.

Non-redirective crash cushions must be checked frequently for vehicle impacts because, once hit, they may not function as designed for a second hit. When sand-filled barrels are fractured, the sand is scattered, site cleanup is needed, and the cushion must be restored with replacement barrels and sand.

2. Truck-Mounted Crash Cushions

Trucks or trailers are often used as protective vehicles to protect workers or work equipment from errant vehicles. These protective vehicles are normally equipped with flashing arrows, changeable message signs, and/or flashers, and must be located properly in advance of the workers and/or equipment they are protecting.

Truck-Mounted Crash Cushions (TMCC) are capable of absorbing the impact of errant vehicles can be attached to the rear of these protective vehicles to reduce the severity of rear-end crashes. There are a variety of TMCC designs available.

The protective truck must be positioned a sufficient distance in front (upstream) of the workers or equipment being

protected to allow for appropriate vehicle roll-ahead, but not so far that errant vehicles will travel around the vehicle and strike the workers/equipment. The cushion should be in the full down-and-locked position. For stationary operations, the truck's parking brake should be set and, when possible, the front wheels turned away from the work site and traffic.

B. Portable Barriers

Portable barriers are designed to prevent vehicles from penetrating work zones behind the barrier while minimizing occupant and worker injuries. They may also be used to separate two-way traffic. These devices may be constructed of concrete, metal, or any material that can physically prevent vehicular penetration.

Portable barriers may serve to channelize traffic. Use for a specific project should be determined by engineering analysis. However, the protective requirements of the work zone, not the channelizing needs, govern the use of portable barriers. When serving the additional function of channelizing traffic, portable barriers should be of a light color for increased visibility. For nighttime visibility, barriers shall be supplemented with standard delineation, markings, or channelizing devices. More specific information on the use of portable barriers and crash cushions can be obtained from the Caltrans Standard Plans and Standard Specifications.

Warning lights may be mounted on continuous barriers. On each side of the

roadway only the first two yellow warning lights at the start of a continuous barrier should be Type A flashing. Subsequent warning lights on the barrier shall be Type C yellow, steady-burning for channelization.

The effect of striking the ends of barriers should be mitigated by use of crash cushions or by flaring the ends of barriers away from the traveled way. See page 5-53 for additional information.

C. Temporary or Portable Traffic Signals

Temporary or portable traffic signals can be used for special applications to control traffic flow at temporary traffic control zones. These applications include a highway intersection with a temporary haul road or equipment crossing, and temporary traffic control zones with alternate one-way traffic flow, such as bridge construction.

All traffic signal and control equipment shall meet the standards and specifications prescribed in Chapter 9 of the Caltrans Traffic Manual and/or the Standard Plans and Special Provisions.

One-way traffic flow requires an all-red interval of sufficient duration for traffic to clear the portion of the temporary traffic control zone controlled by the traffic signals. Temporary or portable traffic signals shall be constructed such as to avoid the display of conflicting signals at each end of the temporary traffic control zone.

D. Rumble Strips

Rumble strips are transverse strips of rough-textured surface used to supplement standard or conventional traffic control devices. Rumble strips may be used to alert drivers of a change in traffic conditions or geometrics or to bring the driver's attention to other warning devices. They provide a vibratory and audible warning that supplements visual stimuli.

Rumble strips are not suitable as a riding surface for bicycles and motorcycles. Where cyclists are permitted, provisions should be made to allow passage through or around the rumble strips.

A rumble strip may consist of raised strips or depressed grooves. The cross-section may be rectangular, domed, or trapezoidal in shape. The strips or grooves should be placed transverse to the direction of traffic. The intervals between rumble strip pads should be reduced as the distance to the condition diminishes, to create a sensation of acceleration for motorists.

The first rumble strip pad should be placed before the advance warning devices. The last rumble strip pad should be placed a minimum of 80 m in advance of the traffic condition or stop position. Rumble strip pads should not be placed on short horizontal or vertical curves where loss of vehicle control could occur because of the action of the rumble strips on a vehicle's suspension system. Rumble strips may be portable devices.

A warning sign may be placed in advance of the strips.

E. Screens.

Screening is used to block the driver's view of activities that can distract from the driving task. Screening also contains the work zone and keeps dust and debris off the pavement. Screens are primarily useful on long-term temporary traffic control projects.

Screens may improve traffic flow where traffic volumes approach the roadway capacity because they discourage "gawking" and reduce headlight glare from oncoming traffic.

Screens may be mounted on the top of portable concrete barriers that separate two-way traffic. Screens should not be mounted where they could restrict driver visibility and sight distance. Additional information regarding screens can be obtained from Chapter 9 of the AASHTO Roadside Design Guide¹, and Chapter 7 of the Caltrans Traffic Manual.

F. Opposing Traffic Lane Divider

Opposing traffic lane dividers are delineation devices used as center lane dividers to separate opposing traffic on a two-way operation. The upright, orange-colored panel shall be approximately 300 mm wide by 450 mm high. The legend on the panel shall be two opposing arrows, similar to those in the legend on the TWO-WAY TRAFFIC sign (W44, page 33). The divider should be made of lightweight reflectorized material. Dividers may be mounted on cones or tubular markers. See Figure 5-10.

¹AASHTO, 44 North Capitol Street, N.W., Suite 225, Washington, D.C. 20001.

Types of Temporary Traffic Control Zone Activities 5-06

5-06.1 Introduction

Each traffic control zone is different. Many variables, such as location of work, road type, speed, volume, geometrics, vertical and horizontal alignment, pedestrians, and intersections affect the needs of each zone. The goal of traffic control in work zones is safety with minimum disruption to traffic; and, the key factor in making the temporary traffic control zone safe and efficient is proper judgment.

Bicyclists also need protection and access to the roadway. If a bikeway is closed because of work in progress, a signed alternate route should be provided. Bicyclists should not be directed onto the same path used by pedestrians. If bicyclists must be directed onto the same path as pedestrians, bicyclists should be directed to dismountings. For more details on controlling bicycle traffic, see Chapter 1000 of the Caltrans Highway Design Manual.

Short-term stationary work takes place both within the roadway and outside the shoulder, to construct and maintain the hardware and equipment used to provide power, light, water, gas, and telephone service. Utility operations are generally short daytime operations, except under emergency conditions. Often they are performed on low-volume, low-speed streets. Operations often involve intersections, as that is where many of the network junctions occur. The crew size is usually small, only a few vehicles are involved, and the number and types of traffic control devices placed in the temporary traffic control zone may be minimal. However, as discussed in Section 5-06.3.A.4, the reduced number of devices in this situation should be offset by the use of high-visibility devices, such as special lighting units on work vehicles. Figures TA5-6, TA5-10, TA5-15, TA5-18, TA5-21, TA5-22, TA5-23, TA5-26 and

TA5-33 are examples of typical applications for short-term stationary operations. Other typicals may apply as well.

In this section, typical temporary traffic control zone situations are organized according to duration and location of work and highway type. Section 5-07, which follows the same organization, presents layouts of these typical temporary traffic control zone situations. Table 5-4, in Section 5-07, indexes by figure number the typical temporary traffic control zone applications described in this section.

5-06.2 Typical Applications

Typical applications include a variety of traffic control methods, but do not include a layout for every conceivable work situation. Typical applications should be altered, when necessary, to fit the conditions of a particular temporary traffic control zone. Standards presented in Sections 5-01 through 5-05 should be given priority over the examples given in the typical applications.

The typical applications illustrated in Section 5-07 generally represent highway agency norms. Other devices may be added to supplement the devices shown in the typical applications, and sign spacings and taper lengths may be increased to provide additional time or space for driver response. In some situations, however, such as an urban setting, too many devices can spread signing over too long a distance to be meaningful. When conditions are not as difficult as those depicted in the typical application, fewer devices may suffice.

Although portable barriers are frequently indicated in the typical applications of Section 5-07, they are not traffic control devices in themselves. However, when placed in a position identical to a line of channelizing devices and marked and/or equipped with appropriate channelizing features to give guidance and warning

both day and night, they serve as traffic control devices and, therefore, must conform to all requirements for such devices set forth throughout this manual.

5-06.3 Selecting the Typical Application

Selecting the most appropriate typical application and modifications for a temporary traffic control zone requires knowledge and understanding of that zone. Although there are many ways of categorizing temporary traffic control zone applications, the three factors mentioned earlier (work duration, work location, and highway type) have been used to characterize the typicals illustrated in Section 5-07.

A. Duration of Work

Work duration is a major factor in determining the number and types of devices used in temporary traffic control zones. The five categories of work duration and their time at a location are as follows:

- Long-term stationary Work that occupies a location more than 3 days.
- Intermediate-term stationary Work that occupies a location from overnight to 3 days.
- Short-term stationary Daytime work that occupies a location from 1 to 12 hours.
- Short-duration-Work that occupies a location up to 1 hour.
- Mobile-Work that moves intermittently or continuously.

1. Long-Term Stationary Work

At long-term stationary traffic control zones, there is ample time to install and realize benefits from the full range of traffic control procedures and devices that are available for use. Generally, larger channelizing devices are used, as they have more retroreflective material and offer better nighttime visibility. The larger devices are also less likely to be displaced or tipped over; an important consideration during those periods when the work crew is not present. Furthermore, as long-term operations extend into nighttime, retroreflective and/or illuminated devices are required. Temporary roadways and barriers can be provided, and inappropriate markings should be removed and replaced with temporary markings.

2. Intermediate-Term Stationary Work

During intermediate-term stationary work, it may not be feasible or practical to use procedures or devices that would be desirable for long-term stationary traffic control zones, such as altered pavement markings, barriers, and temporary roadways. The increased time to place and remove these devices in some cases could significantly lengthen the project, thus increasing exposure time. In other instances, there might be insufficient payback time to make more elaborate traffic control economically attractive.

3. Short-Term Stationary Work

Most maintenance and utility operations are short-term stationary work. The work crew is present to maintain and monitor the temporary traffic control zone. The use of flaggers is an option. Lighting and/or retroreflective devices should be chosen to accommodate varying seasonal, climatic, and visibility situations.

4. Short Duration Work

During short-duration work, there is exposure involved for the crew in setting up and taking down the traffic controls. Also, since the work time is short, the time during which motorists are affected is significantly increased as the traffic control is expanded. Considering these factors, it is generally held that simplified control procedures may be warranted for short-duration work. Such shortcomings may be offset by the use of other, more dominant devices such as special lighting units on work vehicles.

5. Mobile Work

Mobile operations are work activities that move along the road either intermittently or continuously. Mobile operations often involve frequent short stops, each as much as 15 minutes long, for activities such as litter cleanup, pothole patching, or utility operations and are similar to stationary operations. Warning signs, flashing vehicle lights, flags, and/or channelizing devices should be used.

Mobile operations also include work activities in which workers and equipment move along the road without stopping, usually at slow speeds. The advance warning area moves with the work zone. Traffic should be directed to pass. Parking may be prohibited, and work should be scheduled during off-peak hours. For some continuously moving operations such as street sweeping where volumes are light and visibility is good, a well-marked and well-signed vehicle may suffice. If volumes and/or speeds are higher, a shadow or backup vehicle equipped as a sign truck, preferably supplied with a flashing arrow display, should follow the work vehicle. Where feasible, warning signs should be placed along the roadway and moved periodically as the work progresses. In addition, vehicles may be equipped with such devices as flags, flashing vehicle lights, truck-mounted attenuators, and appropriate signs. These devices may be required individually or in various combinations, including all of them, as determined necessary.

Safety should not be compromised by using fewer devices simply because the operation will frequently change its location. Portable devices should be used. Flaggers may be used, but caution must be exercised so they are not unnecessarily exposed to traffic. The control devices should be moved periodically to keep them near the work zone. If mobile operations are in effect on a high-speed travel lane of a multilane divided highway, flashing arrow displays should be used.

B. Location of Work

The choice of traffic control needed for a temporary traffic control zone depends upon where the work is located. As a general rule, the closer the work is to traffic, the more control devices are needed.

Work can take place in the following locations:

1. ***Outside of the shoulder edge.*** Devices may not be needed if work is confined to an area 4.6 m or more from the edge of the shoulder. Consideration should be given to roadway characteristics, roadway geometrics, and vehicle speed. A general warning sign like ROAD MACHINERY AHEAD should be used if workers and equipment must occasionally move closer to the highway.
2. ***On or near the shoulder edge.*** The shoulder should be signed as if work were on the road itself, since it is part of the drivers' "recovery area." Advance warning signs are needed. Channelizing devices are used to close the shoulder, direct traffic, and keep the work space visible to the motorist. Portable barriers may be needed to prevent encroachment of errant vehicles into the work space and to protect workers.
3. ***On the median of a divided highway.*** Work in the median may require traffic control for both directions of traffic, through the use of advance warning signs and channelization devices. If the median is narrow, with a significant

chance for vehicle intrusion into long-term work sites and/or crossover accidents, portable barriers should be used.

4. ***On the traveled way.*** Work on the traveled way demands optimum protection for workers and maximum advance warning for drivers. Advance warning must provide a general message that work is taking place, information about specific conditions, and actions the driver must take to drive through the temporary traffic control zone.

C. Roadway Type

Roadway type is also a primary factor in the use of temporary traffic control devices. Typical application diagrams of the following categories of roadway type are included in Section 5-07:

1. Rural Two-lane Roadways
2. Urban Arterial Roads
3. Other Urban Streets
4. Rural or Urban Multilane Divided and Undivided Highways
5. Intersections
6. Freeways

Rural two-lane highways are characterized by relatively low volumes and high speeds. Urban arterial roads often have lower speeds, but they may require significant controls because of higher traffic volumes and closer spacing of such design features as intersections. Other urban streets with light traffic volumes will generally require fewer, but more closely spaced devices. Major arterials and freeways need the

highest type of traffic control, primarily because of high speeds and often high volumes of traffic.

To improve traffic operations, typical designs may be modified to a more elaborate treatment, as indicated by the following:

- Additional devices
 - Additional signs
 - Flashing arrow displays
 - More channelizing devices at closer spacing
 - Temporary raised pavement markers
 - High-level warning devices
 - Portable changeable message signs
 - Portable traffic signals
 - Portable barriers
 - Crash Cushions
 - Screens
 - Rumble strips
- Upgrading of devices
 - A full complement of standard pavement markings in areas of high conflicts
 - Brighter and/or wider pavement markings
 - Larger signs
 - Higher type channelizing devices
 - Barriers in place of channelizing devices
- Improved geometrics at detours or crossovers, giving particular attention to the provisions set forth in Section 5-01.2
- Increased distances
 - Longer advance warning area
 - Longer tapers

- Lighting
 - Temporary roadway lighting
 - Steady-burn lights used with channelizing devices
 - Flashing lights for isolated conditions
 - Illuminated signs
 - Floodlights

When conditions are not as difficult as those depicted in the typical applications, fewer devices may suffice. However, uniformity of devices and their application is always extremely important.

5-06.4 Work Outside of the Shoulder

Traffic control depends primarily on devices such as advance warning signs, flashing vehicle lights, and flags. An advance warning sign should be used when any of the following conditions occur:

- Work will be performed immediately adjacent to the shoulder at certain stages of the activity.
- Equipment may be moved along or across the highway.
- Motorists may be distracted by the work activity.

A typical sign for this situation may be **SHOULDER WORK AHEAD**. If the equipment travels on or crosses the roadway, it should be equipped with appropriate flags, flashing lights, and/or a **SLOW MOVING VEHICLE** symbol.

A typical layout for stationary work outside of the shoulder is shown in Figure TA5-1. Special signing for a blasting zone is shown in Figure TA5-2. A typical layout for short-duration, mobile

and moving work outside of the shoulder and on the shoulder is shown in Figure TA5-4.

5-06.5 Work on the Shoulder

This section describes typical applications that cover shoulder work. It is divided into shoulder work that does and does not interfere with traffic.

A. No Encroachment on Traveled Way

There is no direct interference with traffic. When the shoulder is occupied or closed, the drivers should be advised and the workers should be protected. In some instances, this may require the use of portable barriers if work is directly adjacent to the travel lane. Usually, the single warning sign, SHOULDER WORK AHEAD, is adequate. When an improved shoulder is closed on a high-speed highway, it should be treated as a closing of a portion of the road system because drivers expect to be able to use it in emergencies. Motorists should be given ample advance warning that shoulders are closed to use as refuge areas throughout a specified length of the approaching temporary traffic control zone. The signs should read SHOULDER CLOSED with distances indicated. The work space on the shoulder should be closed off by a taper of channelizing devices with a length of $1/3 L$, using the formulas in Section 5-02.3. Flashing arrow signs, when used, shall be used only in the caution mode.

B. Minor Encroachment on Traveled Way

When work is on the shoulder or takes up part of a lane, traffic volumes, vehicle mix (buses, trucks, and cars), speed, and

capacity should be analyzed to determine whether the affected lane should be closed. The lane encroachment should permit a remaining lane width of 3 m or the lane should be closed. However, 2.7 m is acceptable for short-term use on low-volume, low-speed roadways for traffic that does not include longer and wider heavy commercial vehicles. Figure TA-6 illustrates a method for handling traffic where the stationary or short duration work space encroaches slightly into the traveled way.

5-06.6 Work Within Traveled Way-Rural Two-Lane

A. Detours

Typical layouts for detours of two-lane highways are shown in Figures TA5-7, TA5-8, and TA5-9. Figure TA5-7 illustrates the controls around an area where a section of roadway has been closed and a bypass constructed. Channelizing devices and pavement markings are used to indicate the transition to the temporary roadway.

Detour signing is usually handled by the traffic engineer with authority over the roadway because it is considered a traffic routing problem. Detour signs are used to direct traffic onto another roadway. When the detour is long, signs should be installed to periodically remind and reassure drivers that they are still on a detour. This is done by using the DETOUR sign (C5A).

When an entire roadway is closed, as illustrated in Figure TA5-8, a detour should be provided and traffic should be warned in advance of the closure. This illustration is an example for a closing 16 km from the

intersection. If local traffic is allowed to use the roadway up to the closure, the ROAD CLOSED TO THRU TRAFFIC sign should be used. The portion of the road open to local traffic should have adequate signing, marking, and protection.

Detours should be signed so that traffic will be able to get through the entire area and back to the original roadway as shown in Figure TA5-9.

B. One-Way Traffic Control

When one lane is closed on two-lane, two-way roads, the remaining lane must be used by traffic traveling in both directions. Techniques for controlling traffic under such conditions are described in Section 5-02.5.

5-06.7 Work Within Traveled Way-Urban Streets or Arterial

Urban temporary traffic control zones may be divided into segments. Decisions must be reached as to how to control vehicular traffic, how many lanes are required, or whether any turns should be prohibited at intersections. Pedestrian traffic must be considered. If work will be done on the sidewalk, it may be necessary to close the sidewalk and assign the pedestrians to another path. Next, decisions must be reached as to how to maintain access to business, industrial, and residential areas. Even if the road is closed to vehicles, pedestrian access and walkways must be provided.

Bicyclists' protection and access are especially needed on these types of roadways. If a bikeway is closed because of the work being done, a signed alternate route should be provided. Bicyclists should not be directed onto the path used by pedestrians. For more details on controlling bicycle traffic, see Chapter 1000 of the Caltrans Highway Design Manual.

Utility work takes place both within the roadway and outside the shoulder to construct and maintain the hardware and equipment. Utility operations are generally daytime operations, except under emergency conditions. Often they are performed in low-volume and low-speed streets. Operations often involve intersections, since that is where many of the network junctions occur. The crew size is usually small, only a few vehicles are involved, and the number and types of traffic control devices placed in the temporary traffic control zone may be minimal. However, as discussed in Section 5-06.3.A.4, in this situation the reduced number of devices should be offset by the use of high-visibility devices, such as special lighting units on work vehicles. Figures TA5-6, TA5-10, TA5-15, TA5-18, TA5-21, TA5-22, TA5-23, TA5-26, and TA5-33 are examples of typical applications for utility operations. Other typicals may apply as well.

5-06.8 Work Within Traveled Way-Rural or Urban, Multilane Divided and Undivided, Non-Access Controlled

This section describes typical applications for work on multilane (four or more) streets or highways. It is divided into right lane closures, left lane closures, multiple-lane closures, and closures on five-lane roadways.

Figure TA5-34 illustrates a lane closure in which portable concrete barriers are used. As described in Section 5-05.9, portable barriers are not in themselves traffic control devices but, if placed along an adequate taper, transition, or tangent section, they may serve as traffic control devices to provide guidance and warning to passing motorists. In serving this traffic control function, portable barriers must be equipped with appropriate channelizing devices, delineation, and/or other traffic control devices in order to perform acceptably during day and night operations. When determined necessary by an engineering analysis,

barriers should be used to prevent incursions of errant vehicles beyond their designated travel lanes. The four primary functions of barriers are as follows:

- To keep traffic from entering work zones, such as excavations or material storage sites.
- To provide protection for workers and pedestrians.
- To separate two-way traffic.
- To protect roadwork such as false work for bridges and other exposed objects.

A. Right Lane Closed

Traffic control similar to that shown in Figure TA5-33 may be used for undivided or divided four-lane roads. If traffic volumes are high, traffic may back up. If morning and evening peak hourly traffic volumes in the two directions are uneven and the greater volume is on the side where the work is being done, the inside lane for opposing traffic may be closed and made available to the side with heavier traffic, as shown in Figure TA5-31. A volume check in both directions should be made before this method is used.

If the heavier traffic changes to the opposite direction, the traffic control can be changed to allow two lanes for opposing traffic by moving the devices from the opposing lane back to the centerline. If these changes occur frequently, cones or tubes should be used at close spacing to emphasize the centerline.

B. Left Lane Closed

If the work activity can be contained entirely within the left (or inside) lane, it may be appropriate to close only that lane. Channelizing devices should be placed along the centerline and outside of the work activity to give advance warning to the opposing traffic. An alternative is to close the two center lanes, as shown in Figure TA5-30, to give motorists and workers additional protection and to provide easier access to the work space. Overall needs, evaluated on the basis of existing traffic volumes and speeds in each direction, is the main factor for determining alternatives.

C. Multiple Lanes Closed

When the work occupies multiple lanes for one direction of traffic, the number of lanes remaining open may be reduced to one for each direction as shown in Figure TA5-32. A capacity analysis is necessary before this method is initiated. Traffic should be moved over one lane at a time as shown in Caltrans Standard Plan T10. When both center lanes are closed, traffic controls may be used as indicated in Figure TA5-30. When a roadway must be closed on a divided highway, a median crossover may be used (see Section 5-06.10.B and C). When the directional roadway is closed, inapplicable WRONG WAY signs and markings, and other existing traffic control devices at intersections within the temporary two-lane, two-way operations section, should be covered, removed, or obliterated.

D. Five-Lane Roads

Traffic control for lane closures on five-lane urban or rural roads is similar to other multilane undivided roads. Figures TA5-32 and TA5-34 should be adapted for use on five-lane roads. For short-duration and mobile operations, see Figure TA5-35.

5-06.9 Work Within Traveled Way-Intersections

For work at an intersection, advance warning signs, devices, and markings are to be used as appropriate on all cross streets. The effect of the work upon signal operation should be considered, such as signal phasing for adequate capacity and for maintaining or adjusting detectors in the pavement.

A shoulder closure is done as shown in Figure TA5-4. A minor encroachment is done as shown in Figure TA5-6.

When a lane is closed on the approach side of an intersection, standard lane closure and taper techniques apply, as shown in Figure TA5-21. A turn lane may be used for through traffic.

When a lane must be closed on the far side of an intersection, that lane should be closed on the near side approach, or converted to an exclusive turn lane, as shown in Figures TA5-22, TA5-23, TA5-24, and TA5-25. When traffic is confined to a single approach lane, turning prohibitions should be considered.

If the work is within the intersection, several options exist as follows:

- Keep the work space small so that traffic can move around it, as shown in Figure TA5-26.
- Use flaggers to assign the right-of-way, as shown in Figure TA5-27.
- Do the work in stages so the work space is kept small.
- Reduce traffic volumes by road closing or upstream diversions.

5-06.10 Work Within Traveled Way-Freeways and Expressways

Traffic control issues occur under the special conditions encountered where traffic must be moved through or around temporary traffic control zones on high-speed, high-volume roadways. Although the general principles outlined in the previous sections of the manual are applicable to all types of highways, special consideration should be given to modern, high-speed, access-controlled highways to accommodate traffic in a manner that also adequately addresses the needs of the work forces. The density of traffic on these facilities requires that detailed traffic control procedures be implemented well in advance of work spaces and in a manner that creates minimum turbulence and delay in the traffic stream. These situations may require more conspicuous devices than specified for normal rural or urban street use. However, the same important basic considerations of uniformity and standardization of general principles apply for all roadways.

The year-round, night-and-day intensity of use of expressways and freeways means that there is no season during which work can be scheduled when traffic volumes and density are low. These activities therefore must be performed under extremely heavy traffic conditions.

Traffic controls for short-duration and mobile operations are shown in Figure TA5-35 for local roads and Caltrans Standard Plans T15, T16 and T17 for State highways.

A. Potential Problem Areas

The performance of work under high-speed, high-density traffic on controlled access highways is complicated by many of the design and operational features inherent to their use.

The presence of median dividers that establish separate roadways for directional traffic may also prohibit the closing of that roadway or the diverting of traffic to other lanes. A typical layout for shifting traffic lanes around a work space is shown in Caltrans Standard Plan T10.

Lack of access to and from adjacent roadways prohibits rerouting of traffic away from the work space in many cases.

A major consideration in the establishment of traffic control is the vehicular speed differential which exists and the limited time available for drivers to react to unusual conditions while still providing an activity area that addresses the needs of the work forces. Traffic control for a typical lane closure is shown in Figure TA5-33 and Caltrans Standard Plan T10.

Other conditions exist where work must be limited to night hours, thereby necessitating increased use of warning lights, illumination of work spaces, and advance warning systems.

B. Two-Lane, Two-Way Traffic on One Roadway of a Normally Divided Highway.

Two-lane, two-way operations (TLTWO) on one roadway of a normally divided

highway is a typical application that requires special consideration in the planning, design, and construction phases. As operational problems can arise with the TLTWO, this typical application will be discussed here.

Before including a TLTWO in the traffic control plan for a project, careful consideration should be given to its reasonableness. The following items should be considered during the decision-making process:

- Is a suitable detour available?
- What are the characteristics of the traffic?
- Can traffic be maintained on the shoulder?
- Can temporary lanes be constructed in the median?
- Can the work be accomplished by closing only one directional lane? If this option is selected for consideration, what are the impacts to temporary traffic control zone personnel?
- If a TLTWO is selected, will this result in a shorter contract time?
- Will the TLTWO allow a contractor to perform the work more efficiently and thus result in a substantial decrease in contract cost?
- What is the "track record" of similar installations?

- Are there any width or height restrictions that would preclude the TL TWO or the use of a shoulder or the median as a temporary lane?
- What are the condition of the travel way and shoulder pavements in the proposed TL TWO section? Due to width restriction, traffic may drive on the shoulders, which must be structurally adequate.
- Consider detour using alternate route for one direction of traffic.

The traffic control shall include provision for separating opposing traffic whenever two-way traffic must be maintained on one roadway of a normally divided highway. The TL TWO shall be used only after careful consideration of other available methods of traffic control.

When traffic control must be maintained on one roadway of a normally divided highway, opposing traffic shall be separated either with portable barriers (concrete safety-shape or approved alternate), or with channelizing devices throughout the length of the two-way operation. The use of striping, raised pavement markers, and complementary signing, either alone or in combination is not considered acceptable for separation purposes.

Treatments for entrance and exit ramps within the two-way roadway segment of this type of work are shown in Caltrans Standard Plans T10 and T14.

C. Crossovers

The following are good guiding principles for the design of crossovers:

- Tapers for lane drops should not be contiguous with crossovers.
- Crossovers should be designed for speeds not less than 16 km per hour below the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed of the roadway, unless unusual site conditions require that a lower design speed be used.
- A full array of channelizing devices, delineators, and full-length, properly placed pavement markings are important in providing drivers with a clearly defined travel path.
- Portable concrete barriers and the excessive use of traffic control devices cannot compensate for poor geometric design of crossovers.
- The design of the crossover should accommodate all roadway traffic including bicycles, trucks, and buses.
- A clear area should be provided adjacent to the crossover.

D. Interchanges

Access to interchange ramps on limited access highways should be maintained even if the work space is in the lane adjacent to the ramps. If access is not possible, ramps

may be closed by using signs and Type III barricades (Type I or II if less than 2 weeks.) Early coordination with officials having jurisdiction over the affected cross streets is needed before ramp closings.

Egress to exit ramps should be clearly marked and outlined with channelizing devices. For long-term projects, old pavement markings should be removed and new ones placed. As the work space changes, the access area may be changed. Traffic control work in the exit ramp may be handled as shown in Caltrans Standard Plans T10 and T14. When a work space interferes with an entrance ramp, a lane may need to be closed on the freeway. Work in the entrance ramp may require shifting ramp traffic. Traffic control for both operations is shown in Caltrans Standard Plan T14.

5-06.11 Control of Traffic Through Incident Areas

The primary function of traffic control at an incident area is to move traffic through or around the incident. Also, proper traffic control through incident areas is essential for fire and enforcement agency activities. An incident is an emergency, traffic collision, natural disaster, or special event. Examples include a stalled vehicle blocking a lane, a traffic collision blocking the traveled way, a hazardous chemical spill closing a highway, floods and severe storm damage, a planned visit by a dignitary, or a major sporting event.

Emergencies and disasters may pose severe and unpredictable problems. The ability to install proper traffic control may be greatly reduced in an emergency, and any devices on hand may be used for the initial response as long as they do not themselves create unnecessary additional

problems. If the situation is prolonged, the standard procedures and devices set forth in this manual shall be used. Special events, on the other hand, can be properly planned for and coordinated. This manual provides standards for the proper procedure for closing portions or entire roadways in conjunction with such activities.

Truck Route National Network and hazardous cargo signs are included in Chapter 4 of the Caltrans Traffic Manual. During incidents, longer vehicles may need to follow a different route from automobiles because of bridge, weight, clearance, or geometric restrictions. Also, vehicles carrying hazardous materials may need to follow a different route from other vehicles.

The control of traffic through incident areas is an essential part of fire and enforcement operations. For these operations there must be adequate legislative authority for the implementation and enforcement of needed traffic regulations, parking controls, and speed zoning. Such statutes should provide sufficient flexibility in the application of traffic control to meet the needs of the changing conditions in incident areas.

Maintaining good public relations is necessary. The cooperation of the news media in publicizing the existence of, and reasons for, incident areas and their traffic information can be of great assistance in keeping the motoring public well informed.

Street or highway incident management signs fall into two major categories: regulatory signs and warning signs. Specifications for incident sign design are presented in Section 5-05.2.

The channelizing devices discussed in Section 5-05.6 should be used whenever possible. Flares may be used to initiate traffic control at all incidents or for short-term traffic control such as clearing incident sites, but should be replaced by more permanent devices as soon as practicable.

A short-term road closing caused by an incident such as a traffic collision may block the traveled way. Traffic may be detoured around the incident and back to the original roadway. The jurisdiction having control of the roadway will probably need to determine the detour route and install the signs.

Large trucks are a primary concern in such a detour.

An incident such as a hazardous chemical spill may require closure of an entire highway. Local traffic can adjust to the closure, but through traffic must be guided around the incident and back to the original route.

Application of Devices 5-07

5-07.1 Typical Applications

Section 5-06 contains discussion of typical activities. Section 5-07 presents typical application diagrams for a variety of situations commonly encountered. While not every situation is addressed, the procedures illustrated can generally be adapted to a broad range of conditions. In many instances, it will be necessary to combine features from various typical application diagrams. For example, work at an intersection may present a near-side work zone for one street and a far-side work zone for the other street. These treatments are found in two different diagrams, and a third diagram shows how to handle pedestrian crosswalk closings.

Procedures for establishing temporary traffic control zones vary with such conditions as road configuration, location of the work, work activity, duration, traffic speed, traffic volume, and pedestrians. Examples presented in this section are guides showing how to apply principles and standards. Judgment is needed in applying these guidelines to actual situations and adjusting to field conditions. In general, the procedures illustrated represent the minimum needs for the situation depicted. Other devices may be added to supplement the devices and device spacing may be adjusted to provide additional reaction time or protection. Where the situation being addressed is less than typical, actual conditions may require fewer devices.

5-07.2 General Notes

General notes for various application categories are provided below. Numerous figures and tables found throughout this manual provide guidance for the development of traffic control plans and procedures. Several of these exhibits presented in previous sections are repeated for convenience after the general notes. Note particularly Figure 5-11, which serves as the legend for symbols used in the diagrams.

A. Work Performed on the Roadside (Outside Shoulder)

When work is being performed off the roadway (beyond shoulders yet within the right-of-way), little or no temporary traffic control may be needed. If there is no effect upon traffic, no devices are needed, but this is rarely the case. More commonly, there may be driver distraction, vehicles may be parked on the shoulder, vehicles may be accessing the work site via the highway, or equipment may on occasion need to travel on or cross the roadway to perform the work operation (e.g. mowing). Where these situations pertain, a single warning sign, such as C-22B, will generally suffice.

If vehicles are using the shoulder, a SHOULDER WORK AHEAD sign is appropriate. For mowing operations, the sign MOWING AHEAD may be used. Where the activity is spread out over a distance of more than 3 km, the sign should be repeated approximately every 3 km. A supplementary plate with the message NEXT [X] MILES may be placed below the initial warning sign.

B. Work Performed on Shoulders

When a highway shoulder is occupied, warning is needed to advise the driver to be aware of the workers. As a minimum, the single warning sign SHOULDER WORK is adequate. When work is performed on a paved shoulder 2.4 m or more wide, a transition area is needed in which channelizing devices are placed on a taper of length that conforms to the requirements of a shoulder taper. When paved shoulders of width of 2.4 m or more are closed on freeways and expressways, additional treatment is generally needed to alert traffic to the possibility of a disabled vehicle that cannot get off the traveled way. An initial general warning sign is needed e.g. ROAD WORK AHEAD, followed by a SHOULDER CLOSED sign. Where the end of the shoulder closure extends beyond the distance that can be perceived by motorists, a supplementary plate bearing the message NEXT [X] MILES should be placed below the SHOULDER CLOSED sign.

When the shoulder is not occupied but work has adversely affected its condition, the LOW SHOULDER or SOFT SHOULDER sign should be used, if

appropriate. Where the condition extends over a distance in excess of 1500 m, the sign should be repeated at approximately 1500 m intervals. In addition, a supplementary plate bearing the message NEXT [X] MILES may be placed below the first such warning sign.

On multilane, divided highways, signs advising of shoulder work, or the condition of the shoulder, should be placed only on the side of the affected shoulder.

C. Mobile and Short-Duration Operations

As compared to stationary operations, mobile and short-duration operations are distinct activities that may involve different treatments. More mobile devices are needed (e.g., signs mounted on trucks), and larger, more imposing, and more visible devices can be used effectively and economically. For example, appropriately colored and marked vehicles with flashing or rotating lights, perhaps augmented with signs or arrow displays, may be used in place of signs and channelizing devices. The trade-off is economical because work duration is short. Mobility is essential, the crew is always onsite, and some of the vehicles may be required for the work activity or crew transportation. Safety is not compromised, as numerous small devices are merely replaced by fewer, more dominant and effective devices.

1. Short Duration

Short-duration activities are generally considered to be those in which it takes longer to set up and remove the traffic control zone than to perform the work.

Typically, such operations can be accomplished in 60 minutes or less.

The crew must exercise caution in setting up and taking down a traffic control zone. Also, as the work time is short, the time during which motorists are affected is significantly increased when additional devices are installed and removed. Considering these factors, it is generally held that simplified control procedures are warranted for short-duration activities. Such shortcomings may be offset by the use of other, more dominant devices, such as special lighting units on work vehicles.

2. Mobile Operations

Mobile operations include activities that stop intermittently and then move on (e.g., pothole patching and litter pickup) and those that move continuously (e.g., pavement striping).

With operations that move slowly (less than 5 km/h), it may be feasible to use stationary signing that is periodically retrieved and repositioned in the advance warning area. At higher speeds, trucks are typically used as components of the traffic control zones. Appropriately colored and marked vehicles with signs, flashing or rotating lights, and special lighting panels move as part of a train behind the work vehicles.

Mobile operations that move at speeds greater than 30 km/h, such as snowplowing operations, shall have

appropriate devices on the equipment, (i.e., rotating lights, signs, or special lighting), or shall use a protection vehicle with appropriate warning devices.

D. Lane Closures on Two-Lane Roads

When one lane of a two-lane road is closed, the remaining lane must accommodate both directions of travel. The typical procedure for short-term work is to utilize flaggers to alternate traffic flow, as shown in Figure TA5-10. For long-term operations, a temporary traffic signal, as shown in Figure TA5-12, is an alternative. For low traffic volumes on a minor road, where traffic may be self-regulating, the procedure illustrated in Figure TA5-11 may be used.

E. Lane Closures on Multilane Roads

When a lane is closed on a multilane road, a transition area containing a merging taper is needed. Typically, the advance warning area contains three warning signs, such as ROAD WORK AHEAD, RIGHT or LEFT LANE CLOSED AHEAD, and the Lane Reduction Transition sign.

When an interior lane is closed for use as a work space, consideration should be given to closing an adjacent lane also. This procedure provides additional space for vehicles and materials and facilitates the movement of equipment within the work space. On multilane undivided roads and streets where the left lane is closed, such additional space can be obtained by also closing the left lane in the opposing direction.

F. Work Performed in the Vicinity of Intersections

The typical application diagrams contained herein depict typical urban intersections on arterial streets. Where the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated speed of traffic equals or exceeds 70 km/h additional warning signs may be needed in the advance warning area.

The typical application diagrams for intersections are classified according to the location of the work space with respect to the intersection area (as defined by the extension of curb or edge lines.) Thus, there are three classifications; near-side, far-side and in-the-intersection.

Traffic control zones in the vicinity of intersections may block movements and interfere with normal traffic flows. Such conflicts frequently occur at complex signalized intersections having such features as traffic signal heads over particular lanes, lanes allocated to specific movements, multiple signal phases, and signal detectors for actuated control. Where such potential problems exist, the traffic engineering staff having jurisdiction should be contacted.

It should be recognized that some work spaces may extend into more than one portion of the intersection. For example, work in one quadrant may create a near-side work space on one street and a far-side work space on the cross street. In such instances, the traffic control zone should incorporate features shown in two or more of the intersection and pedestrian typical application diagrams shown herein.

1. Work Space on the Near Side of Intersections

Near-side work spaces, as depicted in Figure TA5-21, are simply handled as a mid-block lane closure. Where space is restricted, as with short block spacings, two warning signs may be used in the advance warning area, and a third "action-type" warning or regulatory sign (e.g., KEEP LEFT) is placed within the transition area. One problem that may occur with a near-side lane closure is a reduction in capacity, which during certain hours of operation could result in congestion and backups.

2. Work Space on the Far Side of Intersections

Far-side work spaces require additional treatment because motorists typically may enter the activity area by straight-through and left or right-turning movements. Merging movements within the intersection should be avoided. Therefore, the applicable principle is to close any lanes on the near-side intersection approach that do not carry through the intersection as lanes shown in Figures TA5-22, TA5-23, TA5-24, and TA5-25. If, however, there is a significant number of vehicles turning from this lane, then it may be advantageous to convert the lane to an exclusive turn lane.

3. Work Space Within the Intersection

Figures TA5-26 and TA5-27 provide guidance as to applicable procedures for work performed within the

intersection. When directing traffic within the intersection, consideration should be given to using a uniformed police officer.

G. Incident Management Situations

The immediate response to an emergency situation must by necessity make use of available devices and equipment. Given the opportunity, however, longer term emergencies should be treated in a manner similar to other temporary traffic control work sites.

H. Features That May Be Added to the Diagrams

The measures described below are useful in increasing conspicuity and visibility of traffic control devices.

1. Flags on Signs

Flags may be placed above signs to enhance their target value and increase motorists' awareness. Flags are useful for daytime operations only.

2. Flashing Lights on Signs

Portable warning lights may be placed above signs to enhance their target value and increase motorists' awareness. Type A low-intensity warning lights are effective at night. Type B high-intensity warning lights are effective for both day and night.

3. Sign Illumination

The retroreflective material used on sign faces returns light to a light source. In some instances, vehicular headlight beams may not illuminate a sign, such as those placed on sharp curves or on crossroads. Likewise, some road users, such as pedestrians and cyclists, may have inadequate head lamps or no head lamps at all. When these situations are encountered, adequate nighttime sign visibility may be obtained using internal or external sign illumination.

4. Lights on Channelizing Devices

For intermediate and long-term operations, consideration should be given to placing portable warning lights on channelizing devices. Lights are especially effective in the following applications: where new travel patterns are established at tapers, shifts, and runarounds; at road closings; on devices placed on horizontal and vertical curves; when adverse weather conditions are anticipated; where headlights may not adequately illuminate retroreflective material on channelizing devices.

5-07.3 Typical Application Diagrams

Table 5-5 is an index of typical application diagrams. The remainder of the chapter contains the typical application diagrams on the right page with notes on the facing page to the left. The legend for the symbols used in the diagrams is provided as Figure 5-11.

Table 5-4 provides numerical values for the taper length 'L', the buffer space, and the advance warning sign spacing 'A' used in the typical application diagrams.

The taper length is discussed in Section 5-02.3. See Table 5-2 for the taper length formulas.

The buffer space is discussed in Section 5-02.2B3. Table 5-1 provides the length of the

buffer space for various speeds. Table 5-1 is repeated on Table 5-4

The advance warning sign spacing is discussed in Section 5-05.2. Table 5-3 provides sign spacing dimensions for various area and road types. Based on engineering judgment, the sign spacing may be adjusted for site specific conditions. The applicable part of Table 5-3 is repeated on Table 5-4.

Table 5-4
Taper Length, Buffer Space and Advance Warning Sign Spacing
Used in Typical Application Diagrams

English Measurements

Length of Taper 'L' in Feet

| Speed in Miles Per Hour* | Width of Offset** | |
|--------------------------|-------------------|---------|
| | 11 Feet | 12 Feet |
| 20 | 73 | 80 |
| 25 | 115 | 125 |
| 30 | 165 | 180 |
| 35 | 225 | 245 |
| 40 | 293 | 320 |
| 45 | 495 | 540 |
| 50 | 550 | 600 |
| 55 | 605 | 660 |
| 60 | 660 | 720 |
| 65 | 715 | 780 |
| 70 | 770 | 840 |

Metric Measurements

Length of Taper 'L' in Meters

| Speed in Kilometers Per Hour* | Width of Offset** | |
|-------------------------------|-------------------|------------|
| | 3.3 Meters | 3.6 Meters |
| 30 | 20 | 22 |
| 40 | 35 | 38 |
| 50 | 55 | 60 |
| 60 | 79 | 86 |
| 70 | 154 | 168 |
| 80 | 176 | 192 |
| 90 | 198 | 216 |
| 100 | 220 | 240 |
| 110 | 242 | 264 |

*Posted speed, off-peak 85th percentile speed prior to work starting, or the anticipated operation speed.

**For other offset widths, apply the formula in Table 5-2.

For State highways, see Traffic Control Systems in the Caltrans Standard Plans.

Length of Longitudinal Buffer Space

| Speed in Miles Per Hour* | Length of Buffer Space in Feet |
|--------------------------|--------------------------------|
| 20 | 35 |
| 25 | 55 |
| 30 | 85 |
| 35 | 120 |
| 40 | 170 |
| 45 | 220 |
| 50 | 280 |
| 55 | 335 |
| 60 | 415 |
| 65 | 485 |
| 70 | 585 |

Length of Longitudinal Buffer Space

| Speed in Kilometers Per Hour* | Length of Buffer Space in Meters |
|-------------------------------|----------------------------------|
| 30 | 10 |
| 40 | 17 |
| 50 | 28 |
| 60 | 43 |
| 70 | 62 |
| 80 | 84 |
| 90 | 106 |
| 100 | 136 |
| 110 | 170 |

*Posted speed, off-peak 85th percentile speed prior to work starting, or the anticipated operation speed.

Advance Warning Sign Spacing 'A'

| Road Type | Distance Between Signs in Feet* |
|------------------------|---------------------------------|
| Urban - 25 mph or less | 200 |
| Urban - 30 mph or more | 350 |
| Rural | 500 |
| Expwy/Fwy | 1000 |

Advance Warning Sign Spacing 'A'

| Road Type | Distance Between Signs in Meters* |
|-------------------------|-----------------------------------|
| Urban - 40 km/h or less | 60 |
| Urban - 50 km/h or more | 100 |
| Rural | 150 |
| Expwy/Fwy | 300 |

*These are suggested distances for Advance Warning Signs, adequate sight distances and proximity to other roadway features may dictate the need for adjustments when placed.

Table 5-5a
Index to Typical Application Diagrams

| Type of Application | Duration of Work | |
|--|---|----------|
| | Stationary* / Short Duration*** | Mobile** |
| Roadside (Outside of Shoulder) - All Roadways Work Beyond the Shoulder Blasting Zone | TA-1 TA-2 | TA-4 |
| Shoulder - All Roadways Work on Shoulders Mobile Operation on Shoulder Shoulder Closed on Limited Access Highway Shoulder Work with Minor Encroachment | TA-3 TA-5 TA-6 | |
| Within Traveled Way - Rural Two-Lane Road Closed with On-Site Detour Road Closed with Off-Site Detour Roads Opened and Closed with Detour Lane Closure on Two-Lane Road Using Flaggers Lane Closure on Low-Volume, Two-Lane Road Lane Closure on Two-Lane Road Using Traffic Signals Temporary Road Closure Haul Road Crossing Work in Center of Low-Volume Road Surveying Along Centerline of Low-Volume Road Mobile Operations on Two-Lane Road | TA-7 TA-8 TA-9 TA-10 TA-11 TA-12 TA-13 TA-14 TA-15 TA-16 | TA-17 |
| Urban Streets Lane Closure on Minor Street Detour for One Travel Direction Detour for Closed Street | TA-18 TA-19 TA-20 | |
| Intersections and Walkways Lane Closure Near Side of Intersection Right Lane Closure Far Side of Intersection Left Lane Closure Far Side of Intersection Half Road Closure Far Side of Intersection Multiple Lane Closures at Intersection | TA-21 TA-22 TA-23 TA-24 TA-25 | |

Table 5-5b

Index to Typical Application Diagrams


















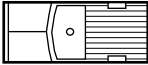



| Type of Application | Duration of Work | |
|---|---------------------------------|----------|
| | Stationary* / Short Duration*** | Mobile** |
| Closure in Center of Intersection | TA-26 | |
| Closure at Side of Intersection | TA-27 | |
| Sidewalk Closures and Bypass Walkway | TA-28 | |
| Crosswalk Closures and Pedestrian Detours | TA-29 | |
| Multilane Undivided | | |
| Interior Lane Closure on Multilane Street | TA-30 | |
| Lane Closure on Streets with Uneven Directional Volumes | TA-31 | |
| Half Road Closure on Multilane High Speed Highways | TA-32 | |
| Multilane Divided | | |
| Lane Closure on Divided Highway | TA-33 | |
| Lane Closure with Barrier | TA-34 | |
| Mobile Operation on Multilane Road | | TA-35 |
| Freeways | | |
| See Standard Plans | | |

* Long-term Stationary: More than 3 days; Intermediate-term Stationary: Overnight up to 3 days; Short-term Stationary: Anytime, more than 60 minutes.

**** Mobile:** Intermittent and continuous moving.

*** Short-duration: Up to 60 minutes

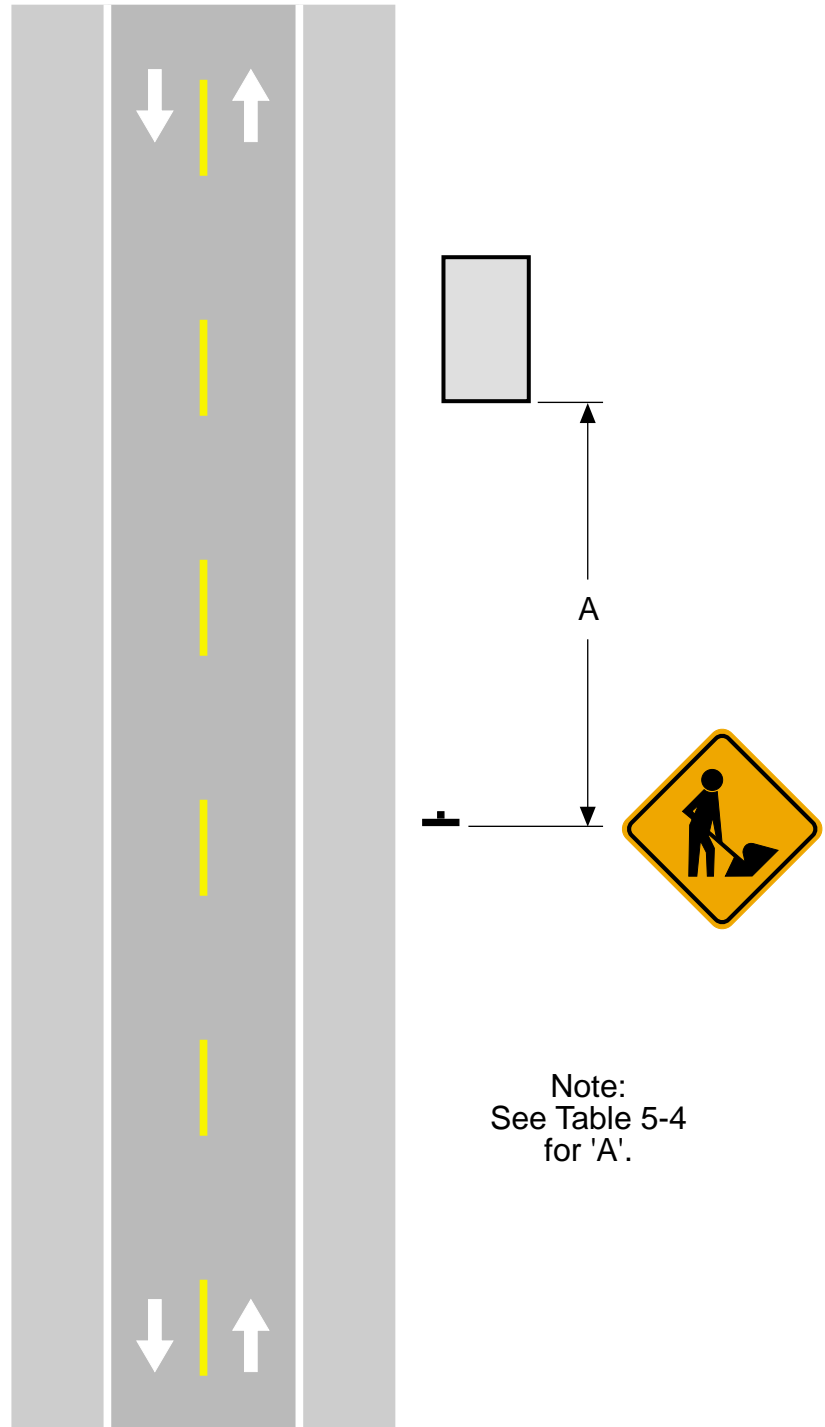
Figure 5-11
Legend of Symbols Used in Typical Application Diagrams

| | | | |
|---|--|---|--------------------------------------|
|  | Flashing Arrow Sign (FAS) |  | Surveyor |
|  | FAS Support or Trailer |  | Traffic or Pedestrian Signal |
|  | Channelizing Device |  | Truck Mounted Crash Cushion |
|  | Direction of Traffic |  | Type III Barricade |
|  | Direction of Temporary Traffic or Detour |  | Changeable Message Sign (CMS) |
|  | Flagger |  | CMS Support or Trailer |
|  | High Level Warning Device (Flag Tree) |  | Warning Light |
|  | Luminaire |  | Work Space |
|  | Pavement Markings that should be removed for a Long Term Project |  | Work Vehicle |
|  | Sign (Shown Facing Left) |  | Portable Barrier with Warning Lights |
|  | Portable Barrier | | |

Work Beyond the Shoulder

1. The signs illustrated in this figure are not required if the work space is behind a barrier, more than 0.6 m behind the curb, or 4.6 m or more from the edge of any roadway.
2. The C-22B WORKER symbol sign may be replaced with other appropriate signs, such as the SHOULDER WORK AHEAD sign. The SHOULDER WORK AHEAD sign may be used for work adjacent to the shoulder.
3. If the work space is in the median of a divided highway, an advance warning sign should also be placed on the left side of the directional roadway.
4. For short-term, short-duration, or mobile operation, all signs and channelizing devices may be eliminated if a vehicle with an activated flashing or revolving yellow light is used.

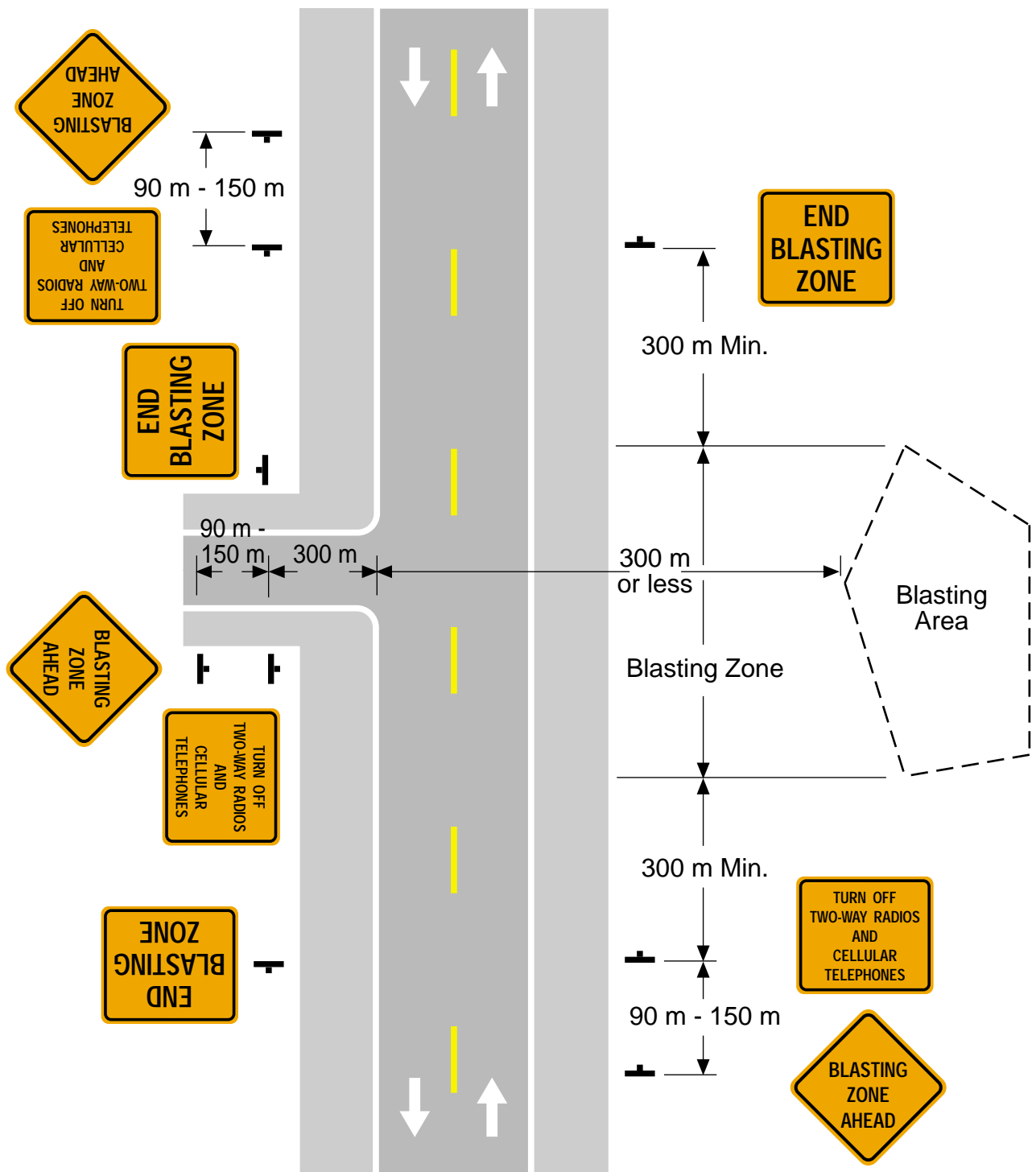
Typical Application 5-1 Work Beyond the Shoulder



Blasting Zone

1. Whenever blasting caps are used within 300 m of a roadway, the signing shown is required. On a divided highway, the signs should be mounted on both sides of the directional roadways.
2. The signs shall be covered or removed when there are no explosives in the area or when the area is otherwise secure.
3. Whenever a side road intersects the roadway between the BLASTING ZONE AHEAD (300 m) sign and the END BLASTING ZONE sign, or a side road is within 300 m of any blasting cap, similar signing, as on the mainline, shall be erected on the side road.
4. Prior to blasting, the blaster in charge shall determine whether highway traffic in the blasting zone will be endangered by the blasting operation. If there is danger, highway traffic shall not be permitted to pass through the blasting zone during blasting operations.

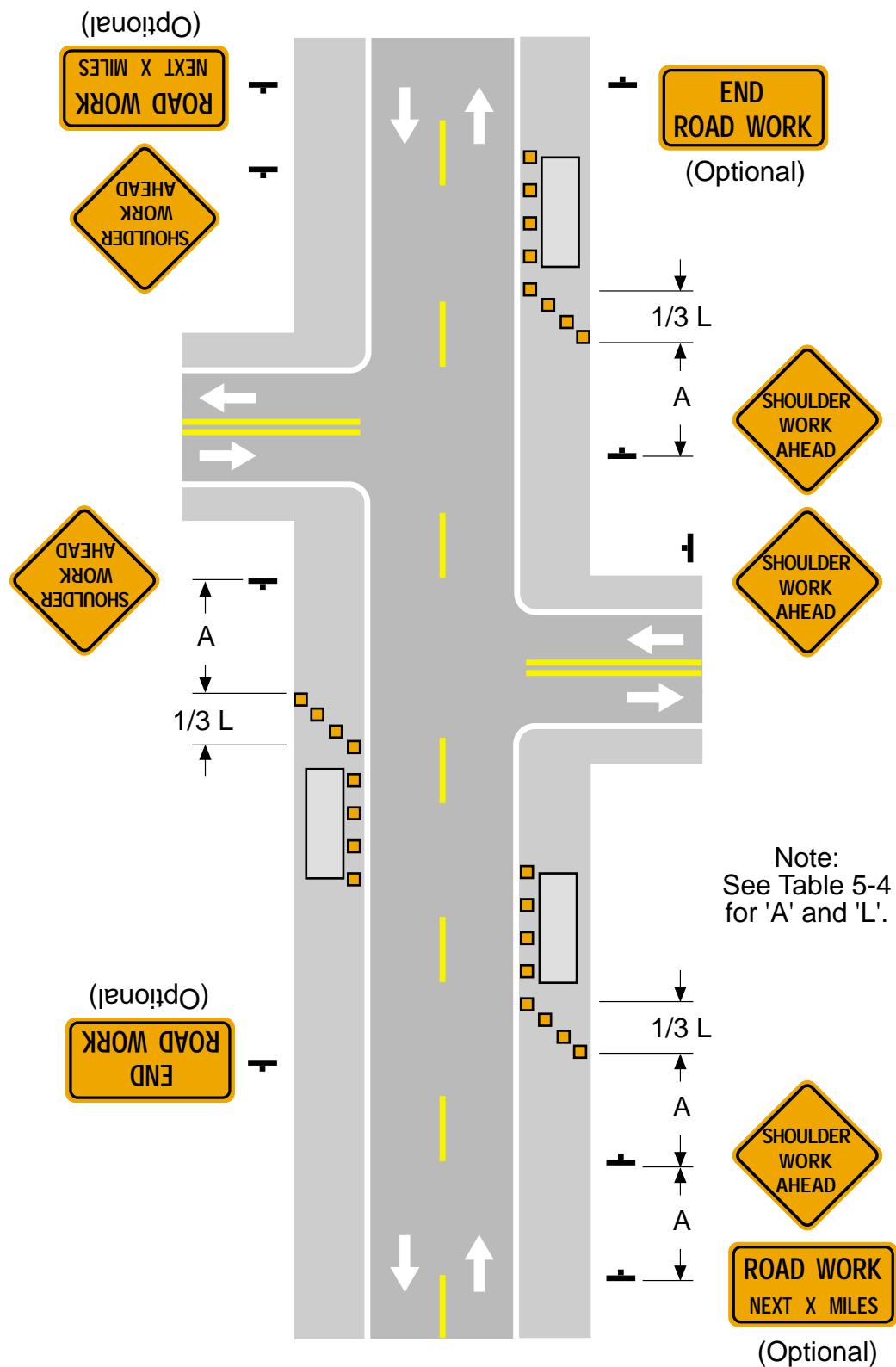
Typical Application 5-2 Blasting Zone



Work on Shoulders

1. The ROAD WORK AHEAD sign on an intersecting roadway is not required if drivers emerging from that roadway will encounter another advance warning sign before they reach this activity area.
2. A SHOULDER WORK AHEAD sign should be placed on the left side of a divided or one-way roadway only if the left shoulder is affected.
3. For short-duration operations 60 minutes or less, all signs and channelizing devices may be eliminated if a vehicle with an activated flashing or revolving yellow light is used.
4. WORKER signs may be used instead of SHOULDER WORK AHEAD signs.

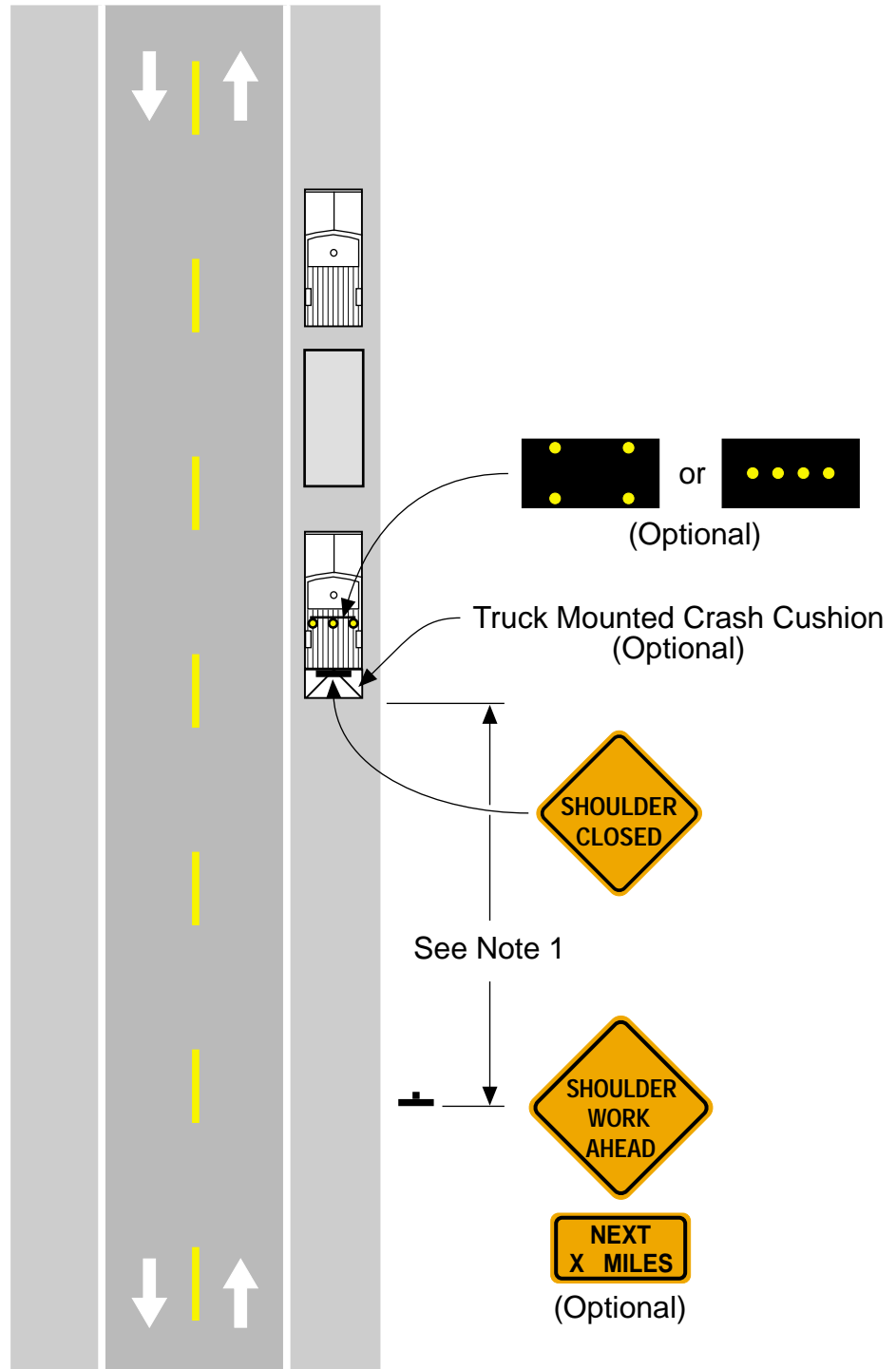
Typical Application 5-3 Work on Shoulders



Mobile Operation on Shoulder

1. In situations where multiple work locations in a limited distance make it practicable to place stationary signs, the maximum spacing for the advance warning sign is 8 km in advance of the work.
2. The length of activity area sign may be used as the stationary advance warning sign if the work locations occur over a distance of more than 3.2 km.
3. Warning signs are not required if the work vehicle displays a flashing or revolving yellow light, if the distance between work locations is 1.6 km or more, and if the work vehicle travels at traffic speeds between locations.

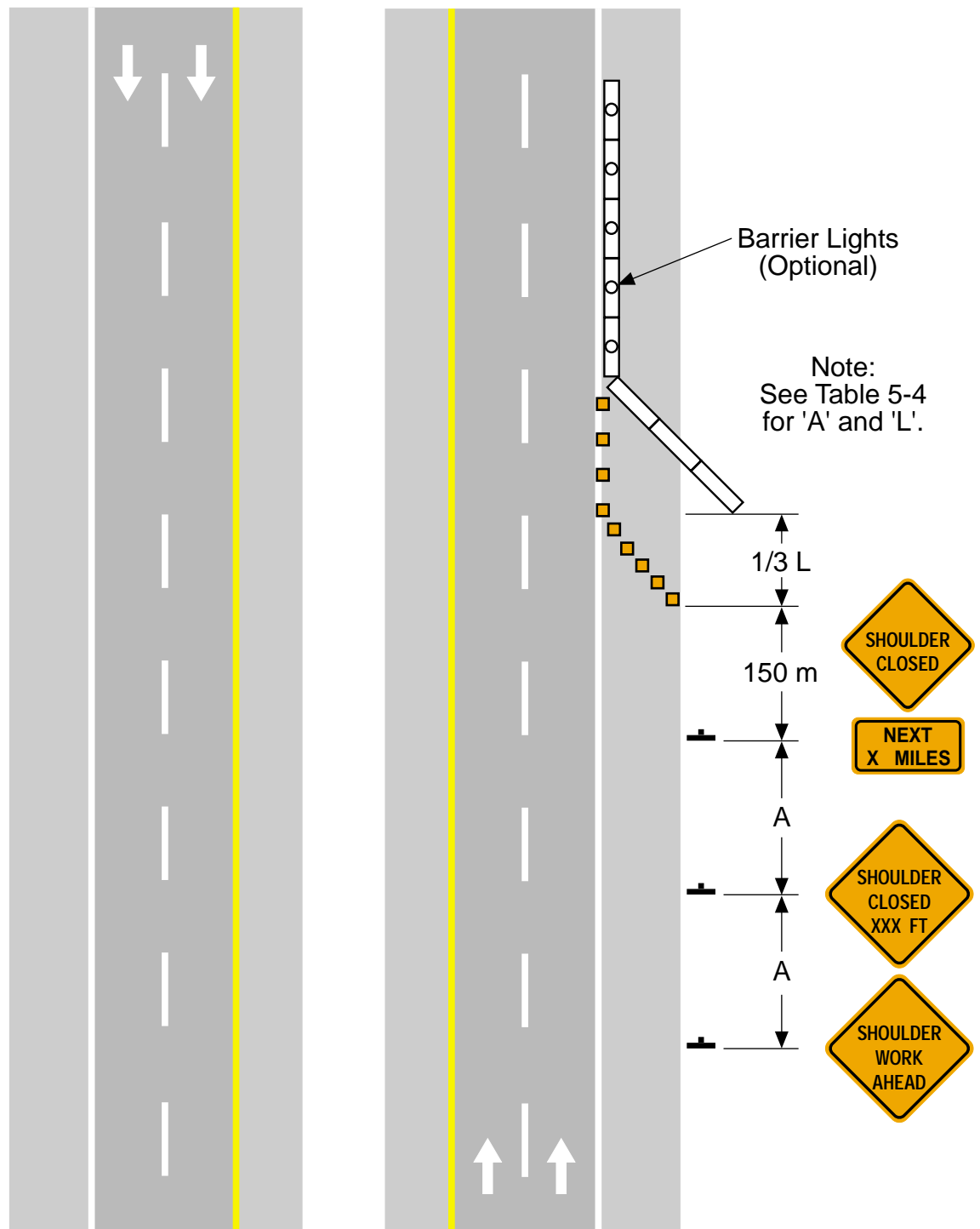
Typical Application 5-4 Mobile Operation on Shoulder



Shoulder Closed on Limited Access Highway

1. SHOULDER CLOSED signs should be used on limited-access highways where there is no opportunity for disabled vehicles to pull off the traveled way.
2. If motorists cannot see a pull-off area beyond the closed shoulder, information regarding the length of the shoulder closure should be provided in meters or kilometers, as appropriate.
3. The barrier in this diagram shows one method that may be used to close a shoulder of a long-term project. The use of a barrier should be based on the need determined by an engineering analysis. The warning lights shown on the barrier are optional.
4. Barriers should be flared beyond the clear zone to prevent vehicles from impacting their leading ends. An alternative procedure is to place a crash cushion to protect traffic from the end of the barrier.

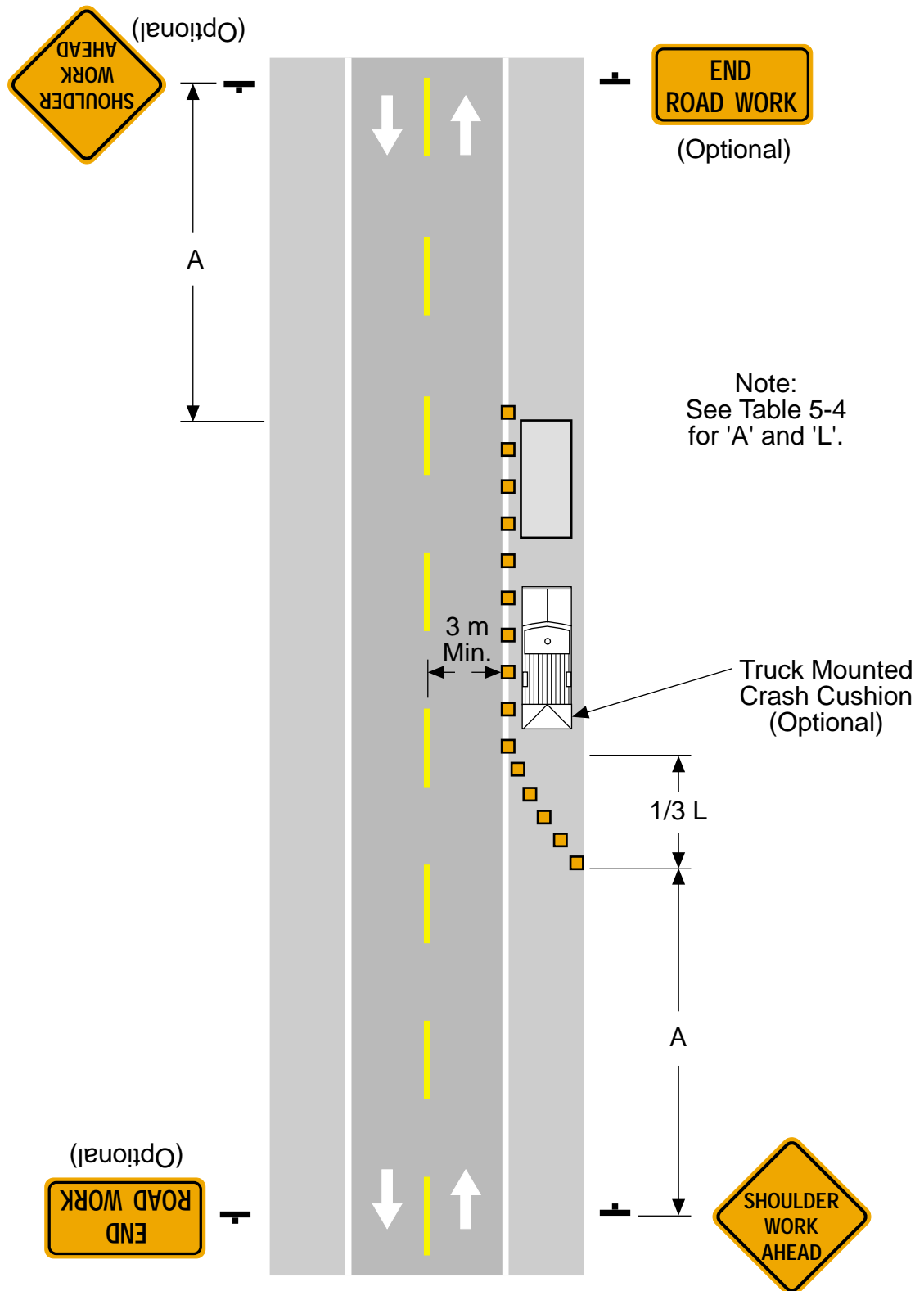
Typical Application 5-5 Shoulder Closed on Limited Access Highway



Shoulder Work with Minor Encroachment

1. The treatment shown may be used on a minor road having low speeds. For higher speed traffic conditions, a lane closure should be considered.
2. The procedure shown should be adequate to carry bidirectional traffic at reduced speed through the activity area, provided the lanes are at least 3 m wide.
3. Where the opposite shoulder is suitable for carrying traffic and of adequate width, traffic lanes may be shifted by use of closely spaced channelizing devices, provided 3 m wide lanes are maintained.
4. Additional advance warning may be appropriate, such as a ROAD (LANE) NARROWS sign.
5. Approved portable barriers may be used along the work space.
6. The protection vehicle is optional if a taper and channelizing devices are used. For short-duration work, the taper and channelizing devices are optional if the protection vehicle with an activated flashing yellow light is used.

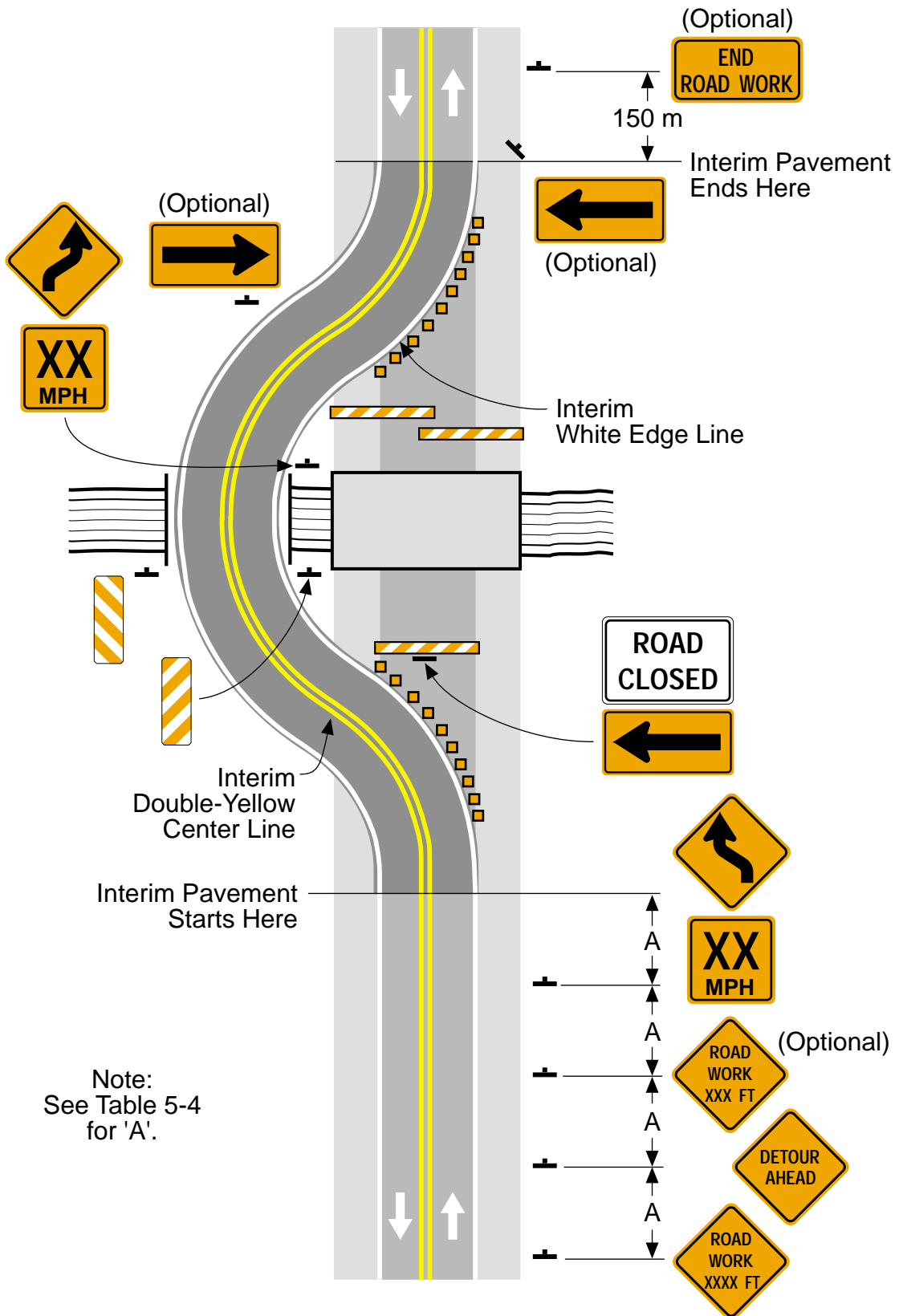
Typical Application 5-6 Shoulder Work with Minor Encroachment



Road Closed with On-Site Detour

1. Signs shown are for one direction of travel only.
2. Flashing warning lights and/or flags may be used to call attention to the initial warning signs.
3. Where the temporary pavement and old pavement are different colors, the temporary pavement should start on the tangent of the existing pavement and end on the tangent of the existing pavement.
4. Pavement markings that are no longer applicable shall be removed or obliterated as soon as practicable.
5. Delineators or channelizing devices may be needed along the bypass roadway.
6. If the detour is short and has sharp curves (50 km/h or less), REVERSE TURN signs should be used with appropriate speed advisory plate. In addition, LARGE ARROW signs may be desirable on sharp curves.
7. For the second reverse curve, when there is insufficient advance warning distance to place a REVERSE CURVE or TURN sign, LARGE ARROW signs should be used on both curves.
8. If the tangent distance along the temporary bypass roadway is short and the curvature is sharp, two LARGE ARROW signs may be required for the second reverse curve.
9. W 81 signs may be used to delineate the curve.

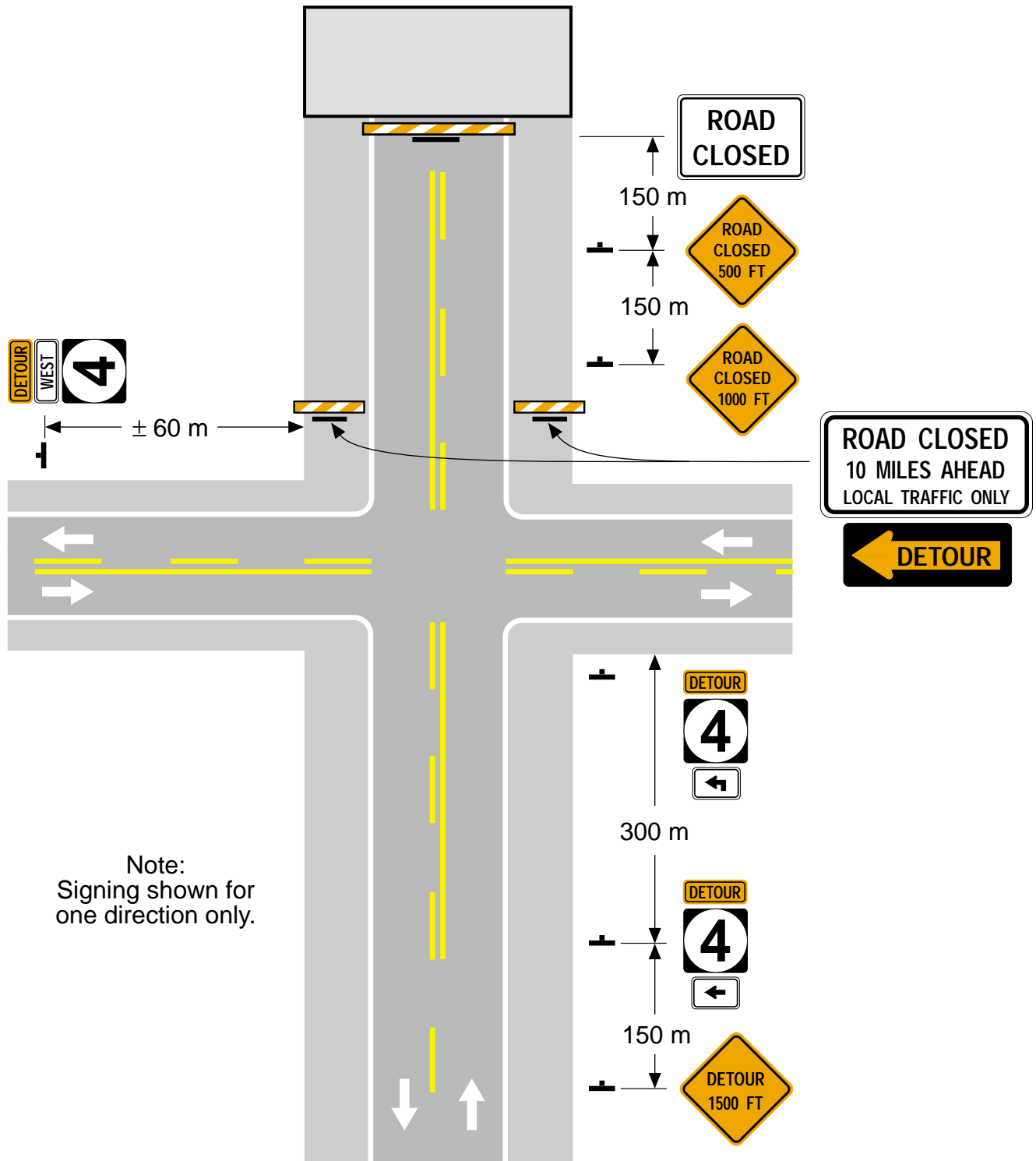
Typical Application 5-7 Road Closed with On-Site Detour



Road Closed with Off-Site Detour

1. Regulatory traffic control devices are to be modified as needed for the duration of the detour.
2. If the road is opened for some distance beyond the intersection and/or there are significant origin/destination points beyond the intersection, place the ROAD CLOSED and DETOUR signs on Type III barricades located at the edge of the traveled way.
3. If the road is closed a short distance beyond the intersection and there are few origin/destination points beyond (e.g., a few residences), the ROAD CLOSED and DETOUR sign may be placed on a Type III barricade placed in the center of the roadway.
4. A route marker directional assembly may be placed on the far left corner of the intersection to augment or replace the one shown on the near right corner.
5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

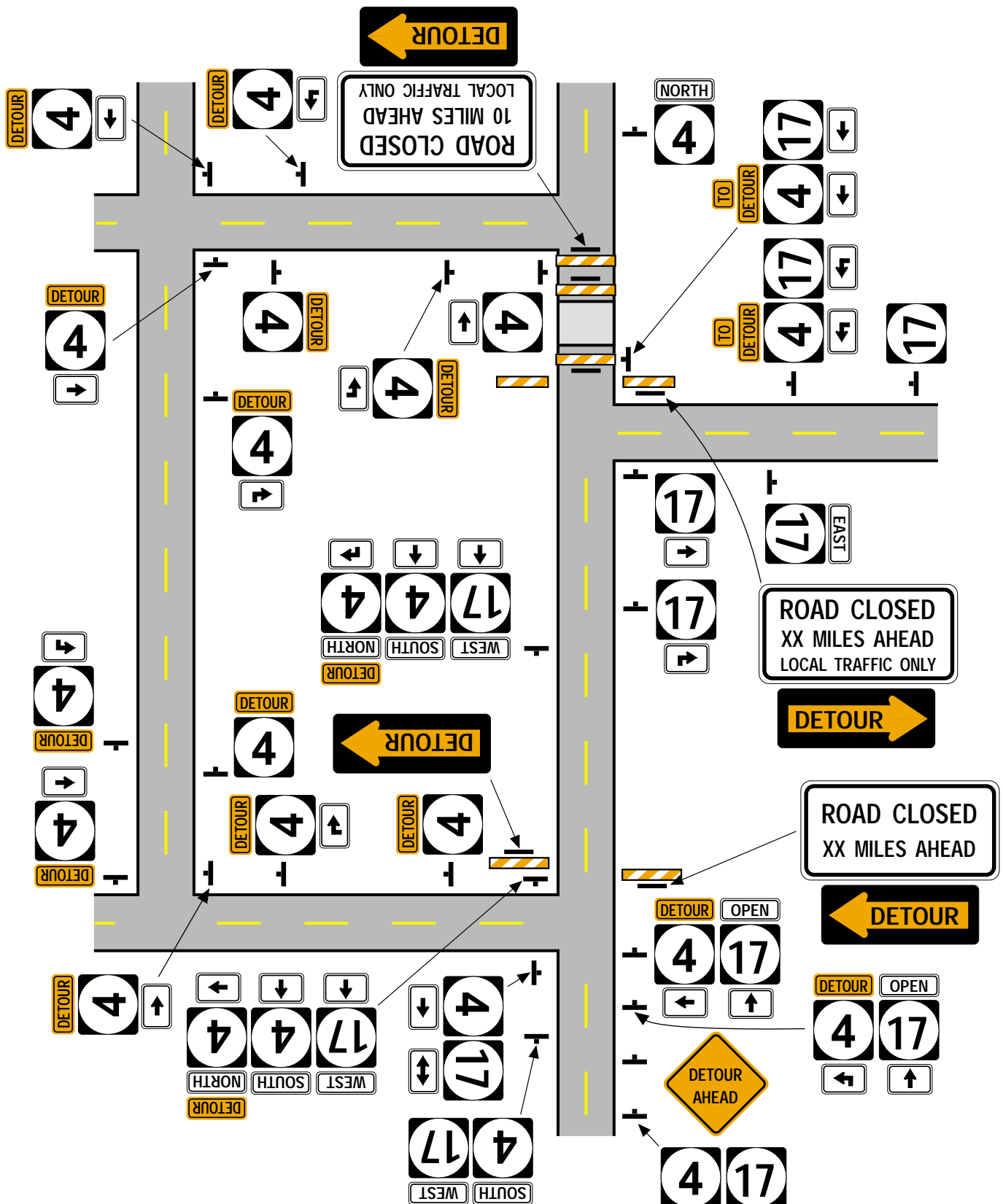
Typical Application 5-8 Road Closed with Off-Site Detour



Roads Opened and Closed with Detour

1. Similar signs and devices shall be erected for the opposite direction.
2. STOP signs displayed to side roads should be erected along the temporary route.
3. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.
4. Flashing warning lights may be used on Type III barricades.

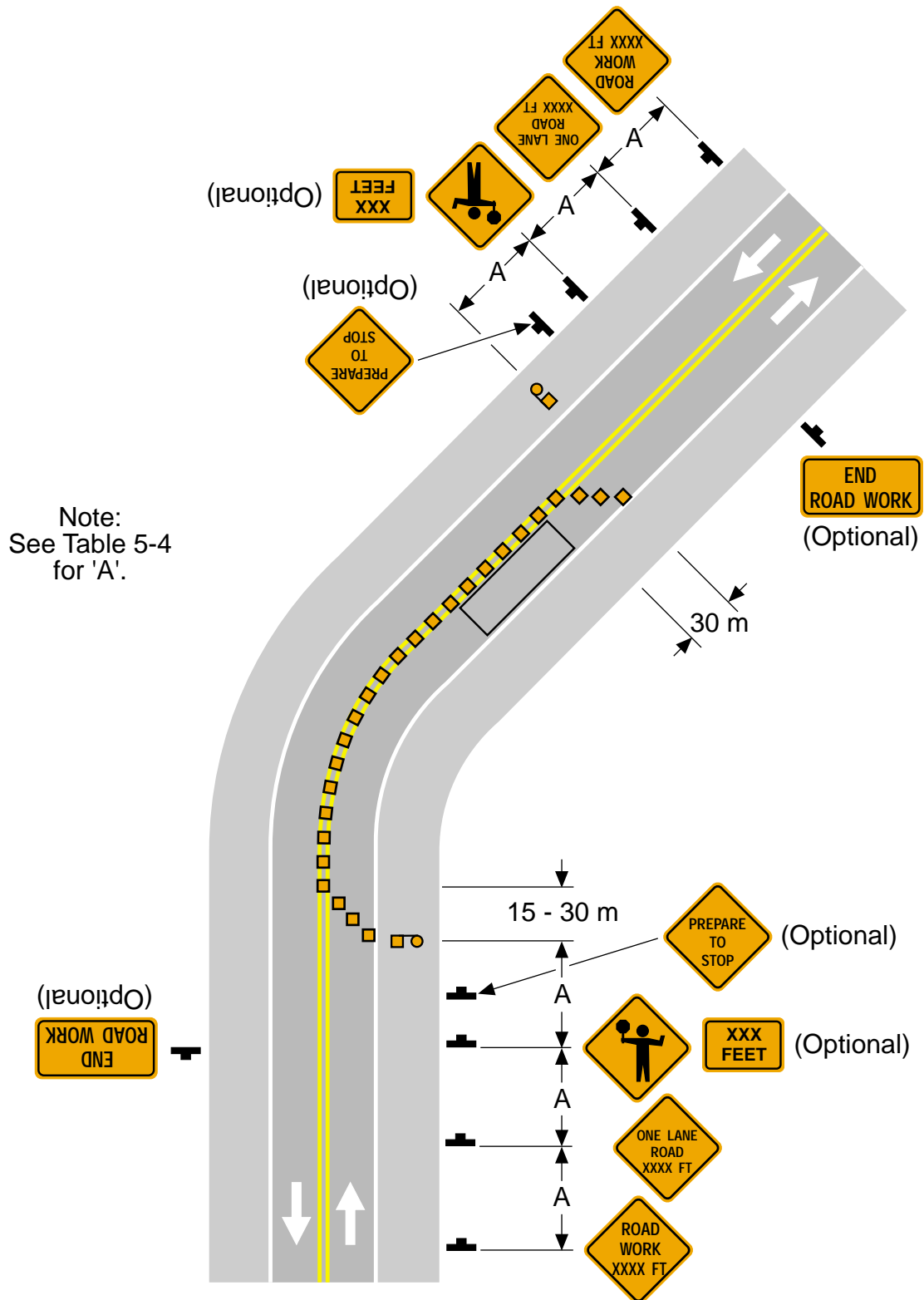
Typical Application 5-9 Roads Opened and Closed with Detour



Lane Closure on Two-Lane Road Using Flaggers

1. Floodlights should be provided to mark flagger stations at night as needed.
2. For low-volume applications, a single flagger may be adequate. Where one flagger can be used, such as for short work zones on straight roadways, the flagger must be visible to approaching traffic from both directions.
3. Channelizing devices are to be extended to a point where they are visible to approaching traffic.
4. The ROAD WORK AHEAD sign may be omitted for short-duration operations or when the end of the work zone is obvious.
5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.
6. For State highways, see Caltrans Standard Plan T13.

Typical Application 5-10 Lane Closure on Two-Lane Road Using Flaggers

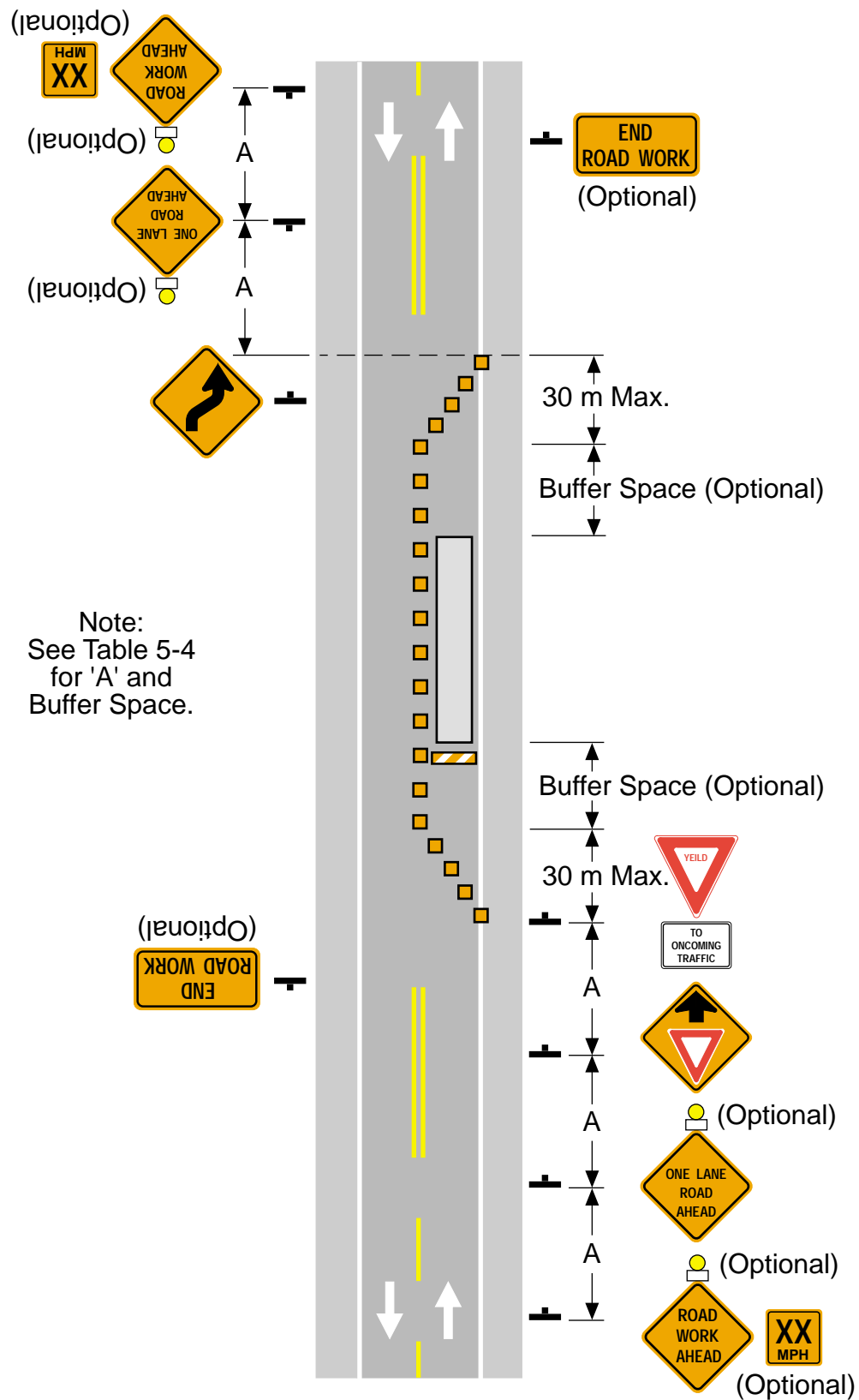


Lane Closure on Low-Volume, Two-Lane Road

1. This temporary application may be used as an alternate traffic control plan to the lane closure with flaggers (TA 5-10), when the following conditions exist.
 - a. Traffic volume is such that sufficient gaps exist for traffic that must yield.
 - b. Drivers from both directions must be able to see approaching traffic through and beyond the work site.
2. The YIELD sign and YIELD AHEAD sign may be covered and flaggers used, as needed, during daylight working hours to control the flow of traffic through the work space. When flaggers are used, the FLAGGER sign shall be used in place of the YIELD AHEAD sign.
3. The Type A flashing warning lights may be placed on the ROAD WORK AHEAD and the ONE LANE ROAD AHEAD signs, whenever a night lane closure is necessary.

Typical Application 5-11

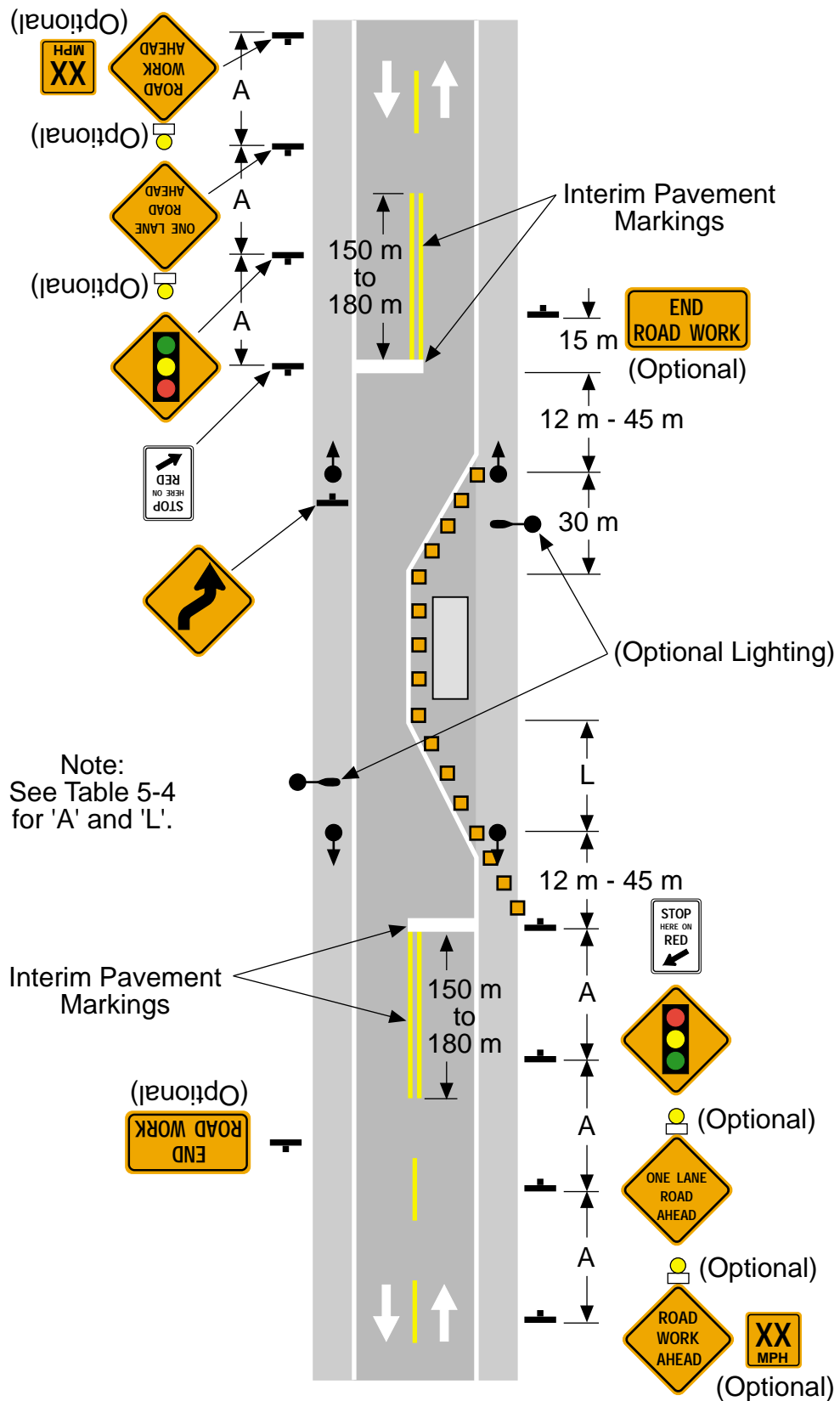
Lane Closure on Low-Volume, Two-Lane Road



Lane Closure on Two-Lane Road Using Traffic Signals

1. Temporary traffic signals are preferable to flaggers for long-term projects and other activities that would require flagging at night.
2. The maximum length of activity area for one-way traffic signal control is determined by the capacity required to handle the peak hour demand. Practical maximum length is 120 m. Signal timing shall be established by qualified personnel.
3. Signals shall be installed and operated in accordance with the requirements of Chapter 9 of the Caltrans Traffic Manual. Temporary traffic control signals shall meet the physical display and operational requirements of conventional traffic signals.
4. Adequate area illumination to clearly identify both ends of the work space at night for long-term operations should be provided.
5. Stop lines 300 to 600 mm wide shall be installed. Add “no-passing” lines when necessary. Removable pavement markings may be used. Conflicting pavement markings and raised pavement marker reflectors between the activity area and the stop line shall be removed. After completion of the work, the stop lines and other temporary inapplicable pavement markings shall be removed.
6. The Type A flashing warning lights shown on the ROAD WORK AHEAD and the ONE LANE ROAD AHEAD signs may be used whenever a night lane closure is necessary. Type B lights may be used to also increase the daytime target value of the signs.
7. The horizontal or vertical alignment of the roadway may require adjustments in the location of the advance warning signs (the distances shown for advance warning sign spacings are minimums). The vertical alignment of the roadway may require adjustments in the height of the signal heads.
8. When the signal is changed to a flash condition either manually or automatically, red shall be flashed to both approaches.
9. CMS may be used to supplement this sign package.

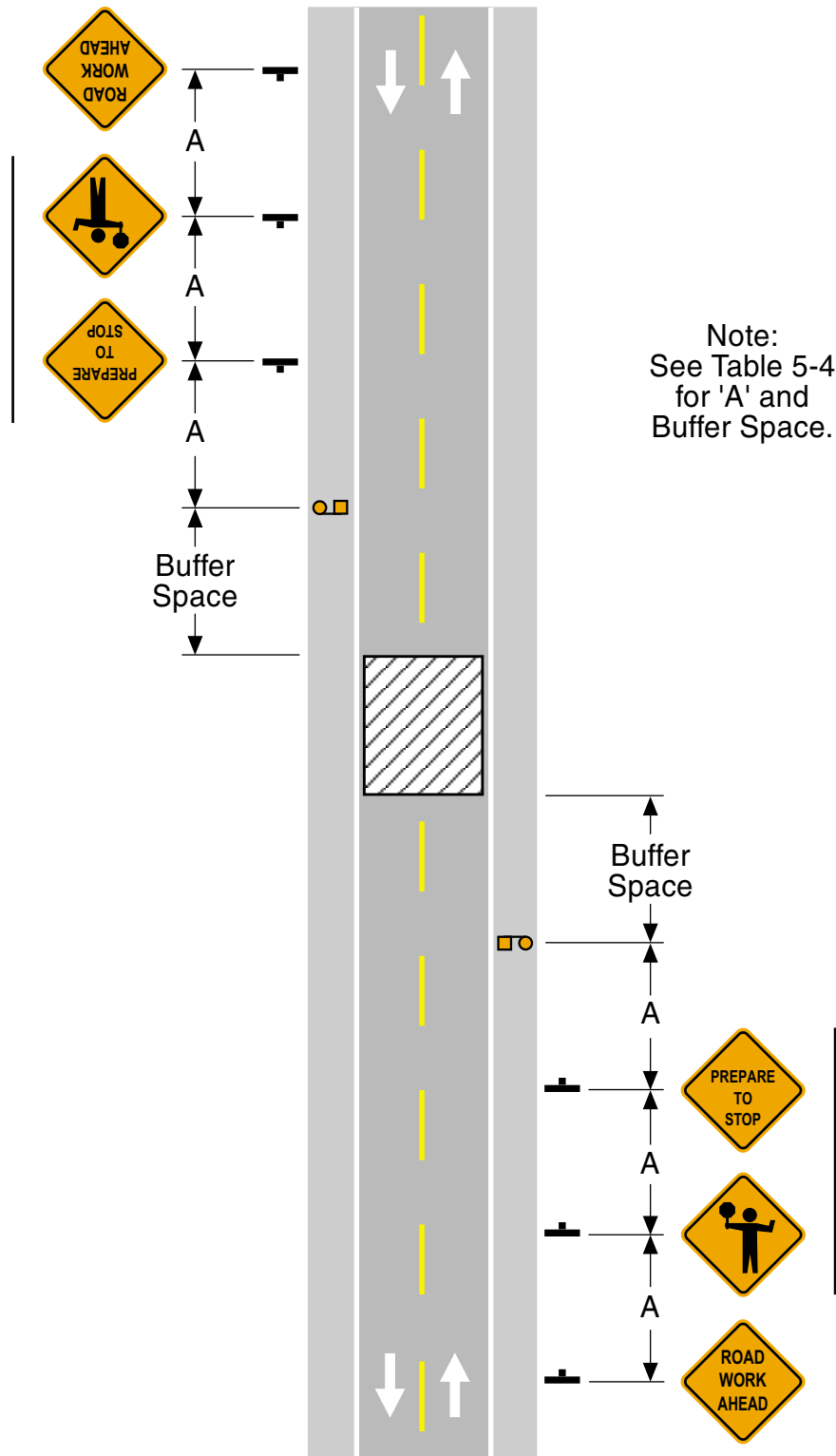
Typical Application 5-12 Lane Closure on Two-Lane Road Using Traffic Signals



Temporary Road Closure

1. Conditions represented are for work that requires closures during daytime hours only.
2. This application is intended for a planned temporary closure not to exceed 15 to 20 minutes.
3. The flaggers shall stop the first vehicle from the position shown, then move to the centerline to stop approaching traffic.
4. For high-volume roads, a police patrol car and/or a changeable message sign may be added.
5. A portable changeable message sign may be used in addition to the initial warning sign, per Section 5-05.3B, Application.

Typical Application 5-13 Temporary Road Closure



Haul Road Crossing

This diagram shows two different methods of traffic control; flagging and a temporary traffic signal. The method selected is to be used in both directions.

Unsignalized Crossing

1. This typical application diagram as shown is intended for short-term use during daylight hours.
2. When the haul road is not in use, Type III barricades shall be in place. The FLAGGER signs shall be covered.
3. The flagger shall stop the first vehicle from the position shown, then move to the centerline to stop approaching traffic.

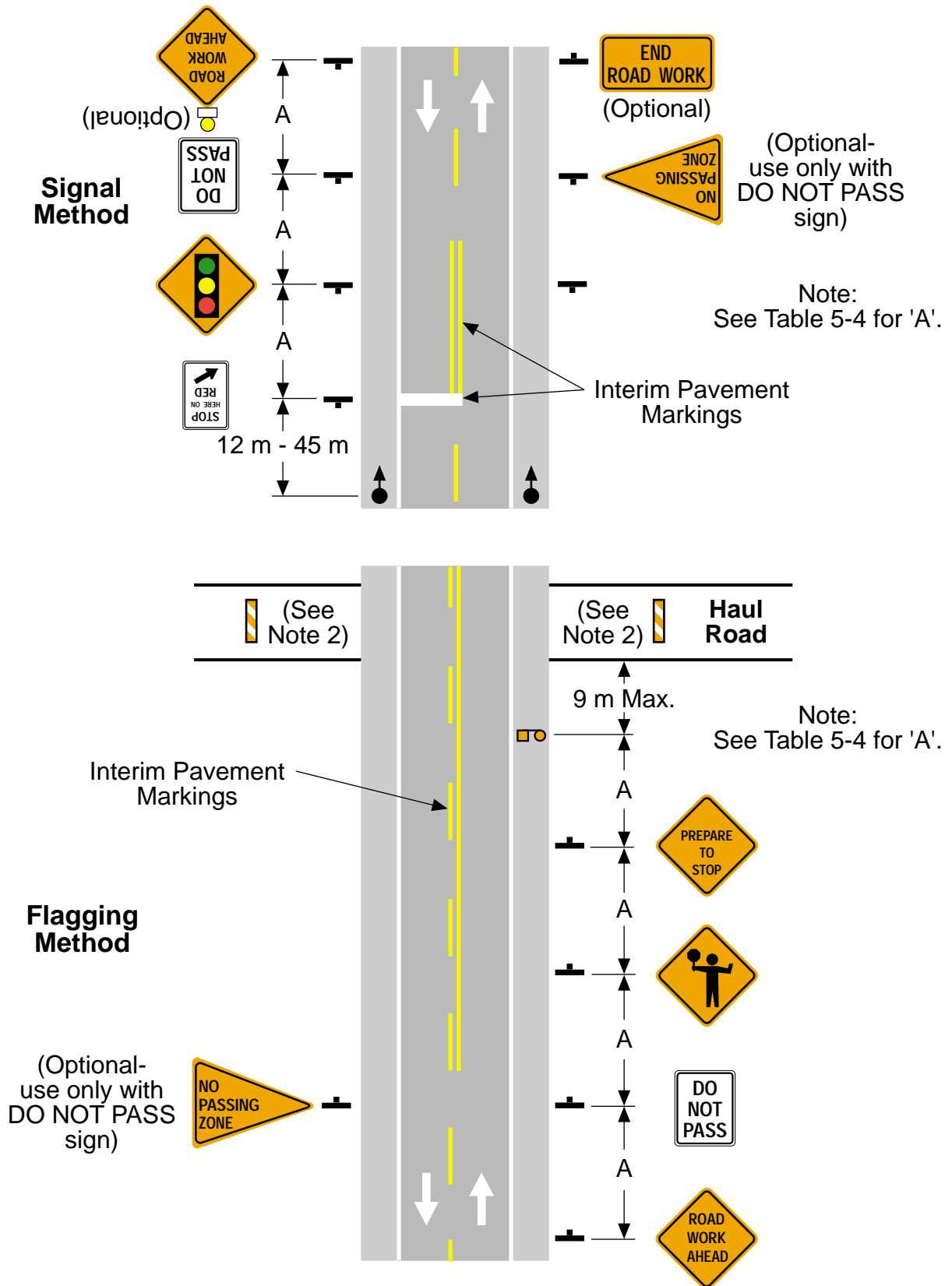
Signalized Crossing

1. Dashed yellow centerline, if existing, between the stop lines shall be removed before the beginning of roadwork and replaced before opening to normal traffic.
2. When the haul road is not in use, Type III barricades shall be in place. The Signal Ahead symbol sign and STOP HERE ON RED sign, and traffic signals, shall be covered or hidden from view.
3. Traffic signals shall be two-direction type with push-button activation. The temporary traffic control signals shall meet the physical display and operational requirements of conventional traffic signals as described in Chapter 9 of the Caltrans Traffic Manual.

Floodlighting

1. When hauling during hours of darkness and existing lighting is inadequate, floodlights should be used to illuminate haul road crossings.

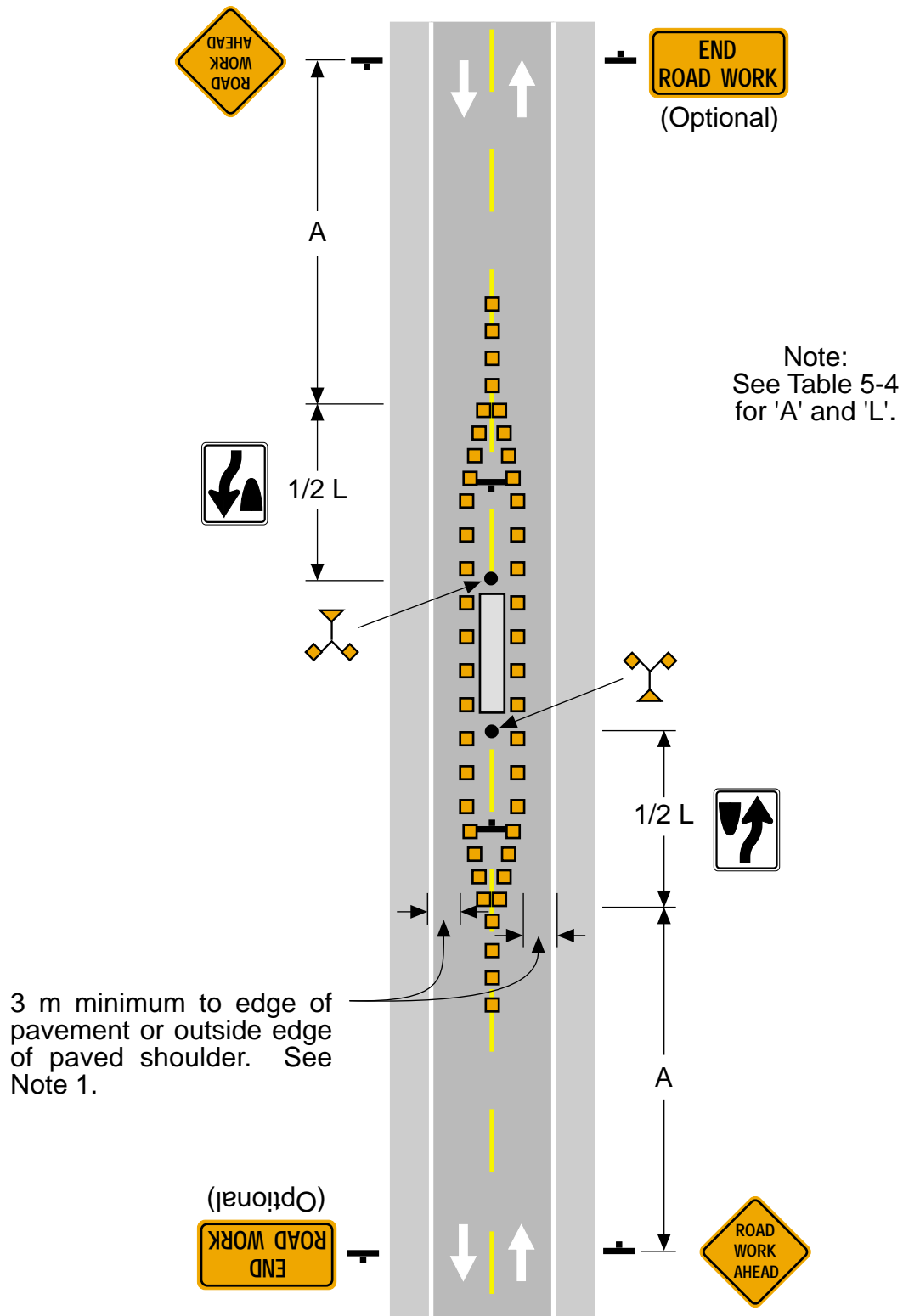
Typical Application 5-14 Haul Road Crossing



Work in Center of Low-Volume Road

1. The lanes on either side of the center work space should have a minimum width of 3 m, as measured from the near edge of the channelizing devices to the edge of pavement, or the outside edge of paved shoulder.
2. A minimum of six channelizing devices should be used for each taper. However, a work vehicle displaying a flashing or revolving yellow light may be used instead of the tapers.
3. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.
4. If the closure continues overnight, warning lights may be used to mark channelizing devices.

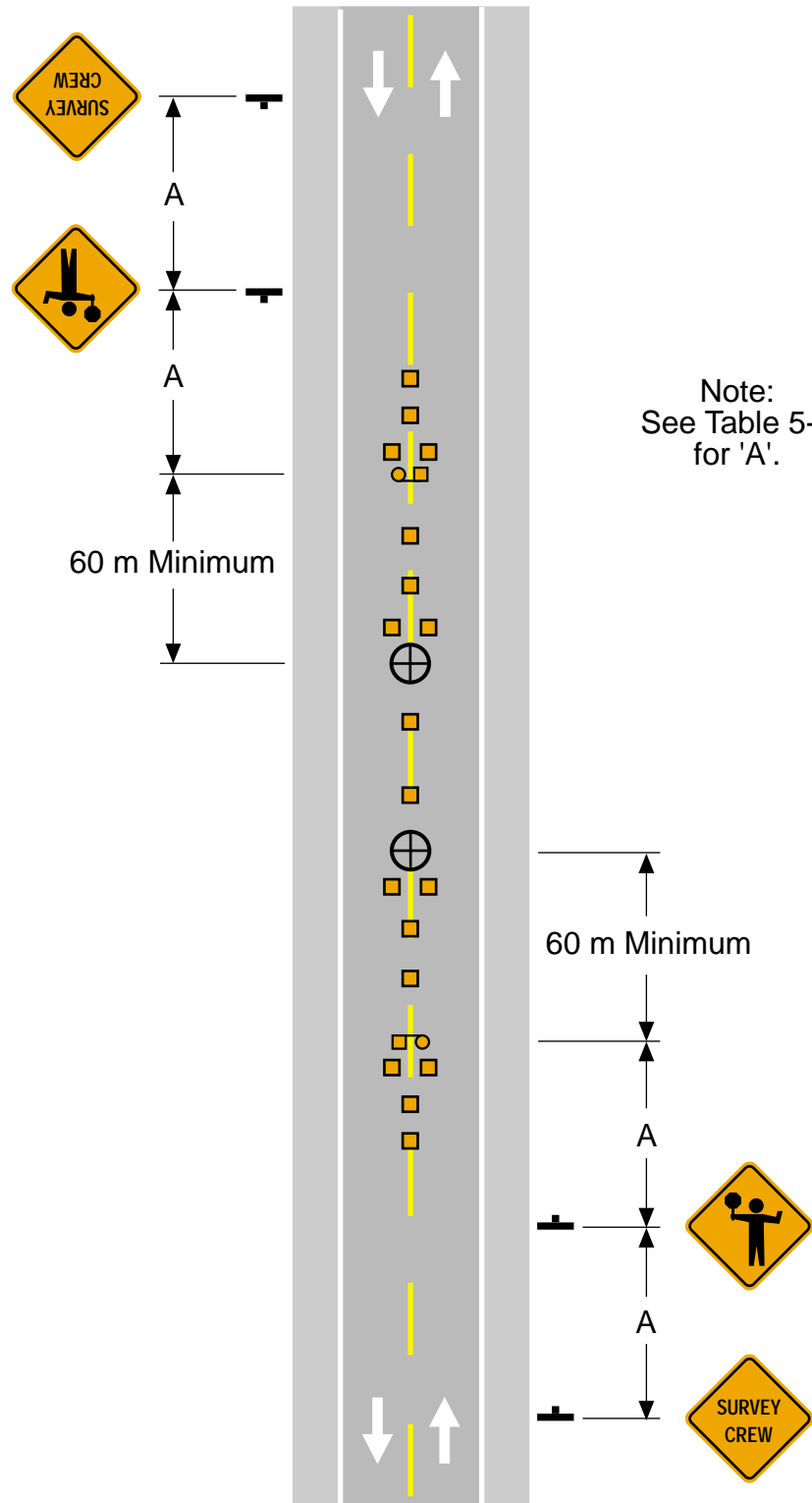
Typical Application 5-15 Work in Center of Low-Volume Road



Surveying Along Centerline of Low-Volume Road

1. The same treatment is required in both directions.
2. Cones should be placed 150 to 300 mm on either side of the center line.
3. Maximum spacing between cones is 30 m.
4. For a survey along the edge of the road or along the shoulder, the advance signing remains the same. For this situation, place cones along the edge line. A flagger is not required for work along the shoulder.
5. Cones may be omitted for a cross-section survey.
6. For surveying on the centerline of a high-volume road, close one lane, using the procedure illustrated in Figure TA-10.
7. ROAD WORK AHEAD signs may be used in place of SURVEY CREW signs.
8. A flagger should be used to protect people who must work with their backs to traffic. A high-level warning device may be used to protect a surveying device, such as a target on a tripod. Workers in the roadway should wear high-visibility clothing.
9. Flags may be used to call attention to the advance warning signs.

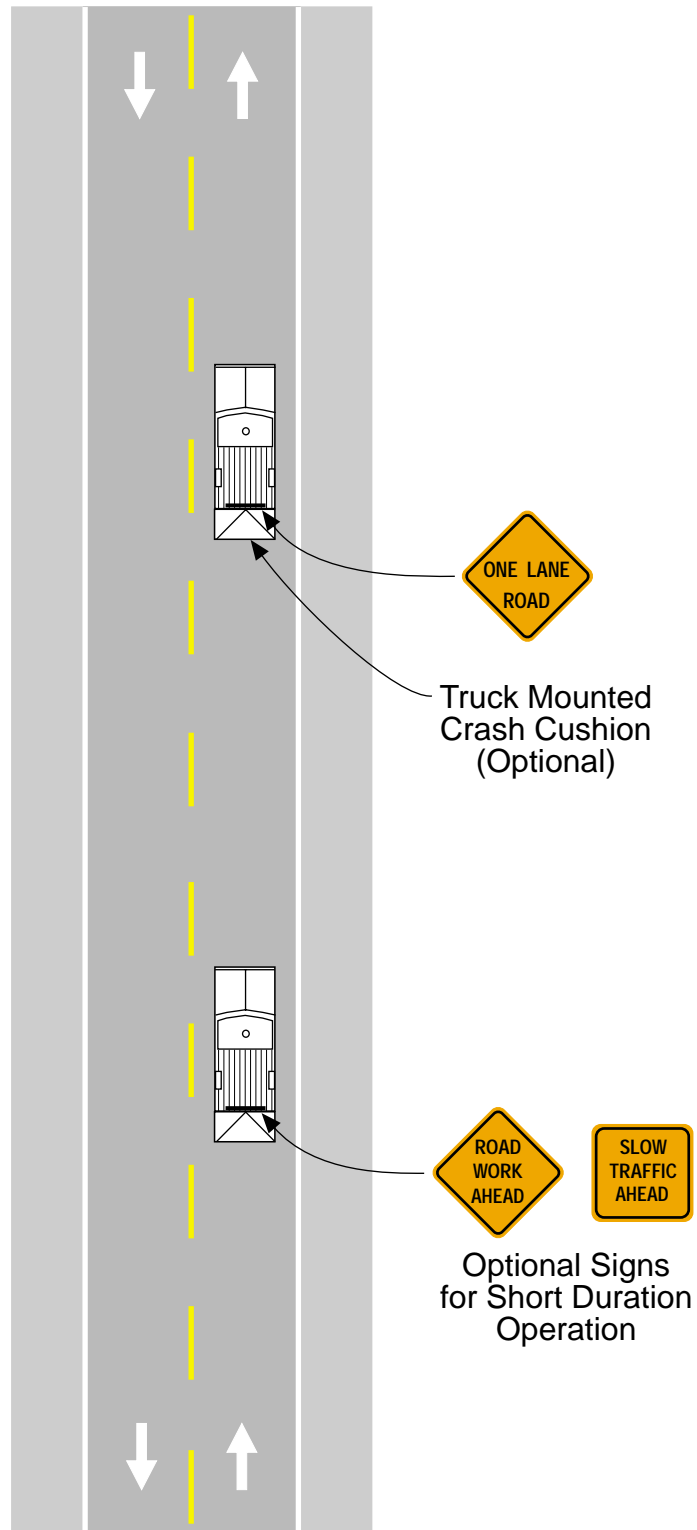
Typical Application 5-16 Surveying Along Centerline of Low-Volume Road



Mobile Operations on Two-Lane Road

1. Where practicable, and when needed, the work and protection vehicles should pull over periodically to allow traffic to pass. If this can not be done frequently, as an alternative, a DO NOT PASS sign may be placed on the rear of the vehicle blocking the lane.
2. The distance between the work and protection vehicles may vary according to terrain, paint drying time, and other factors. Protection vehicles are used to warn traffic of the operation ahead. Whenever adequate stopping sight distance exists to the rear, the protection vehicle should maintain the minimum distance and proceed at the same speed as the work vehicle. The protection vehicle should slow down in advance of vertical or horizontal curves that restrict sight distance.
3. Additional protection vehicles to warn and reduce the speed of oncoming or opposing traffic may be used. Police patrol cars may be used for this purpose.
4. A truck-mounted crash cushion (TMCC) should be used on the protection vehicle and may be used on the work vehicle.
5. The work vehicle shall be equipped with beacons, and the protection vehicles shall be equipped with two high-intensity flashing lights mounted on the rear, adjacent to the sign. Protection and work vehicles should display flashing or rotating beacons both forward and to the rear.
6. Vehicle-mounted signs shall be mounted with the bottom of the sign, at a minimum height of 1.2 m above the pavement. Sign legends shall be covered or turned from view when work is not in progress.

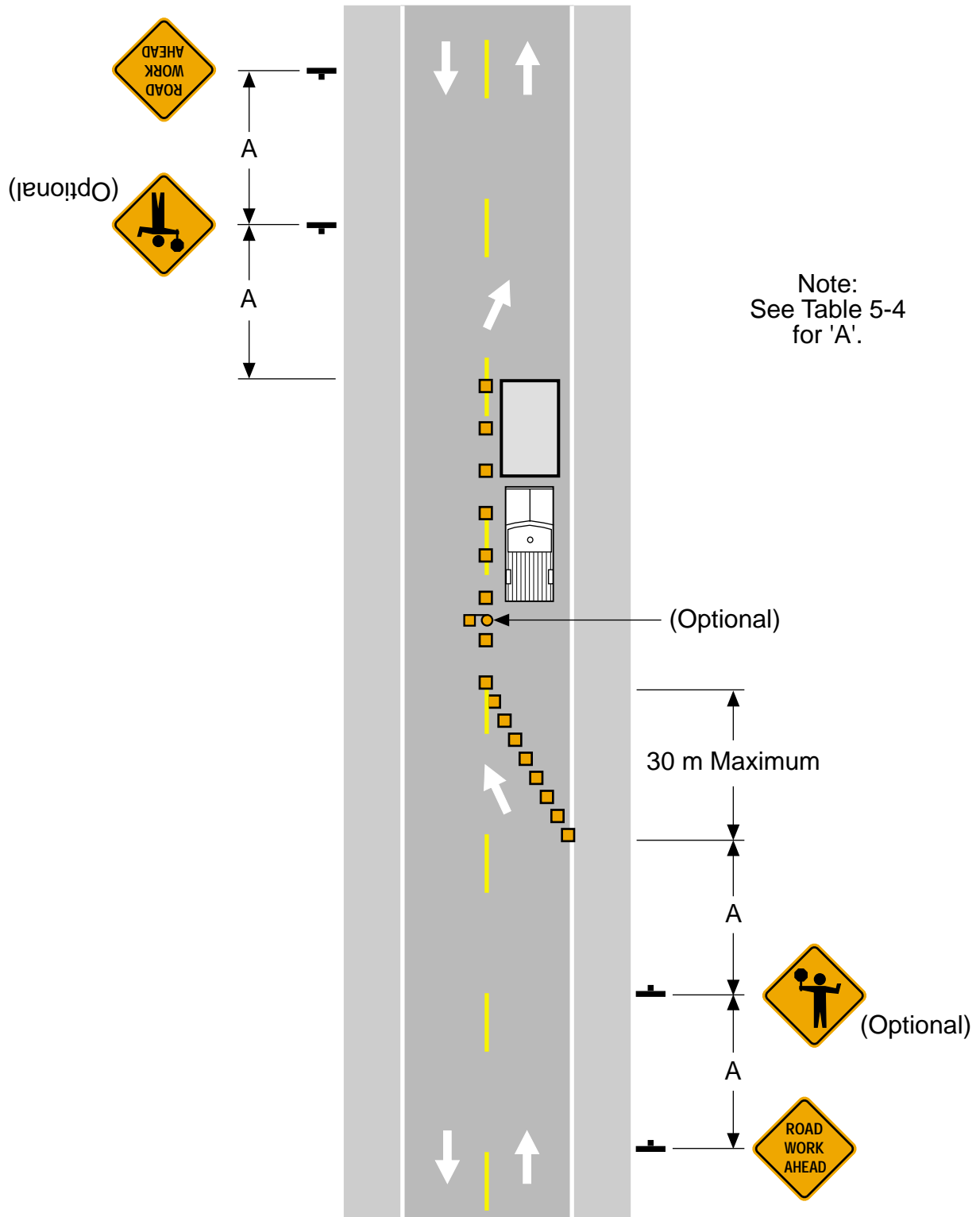
Typical Application 5-17 Mobile Operations on Two-Lane Road



Lane Closure on Minor Street

1. The traffic control procedure shown is appropriate only for low-volume, low-speed facilities, such as local residential streets. With few exceptions, this procedure is not to be used in rural areas. Typical applications of traffic control devices on other roadways are shown in Typical Applications 5-21, 5-22, and 5-23.
2. Traffic can regulate itself when volumes are low and the length of the work space is short, thus enabling drivers to readily see the roadway beyond.
3. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

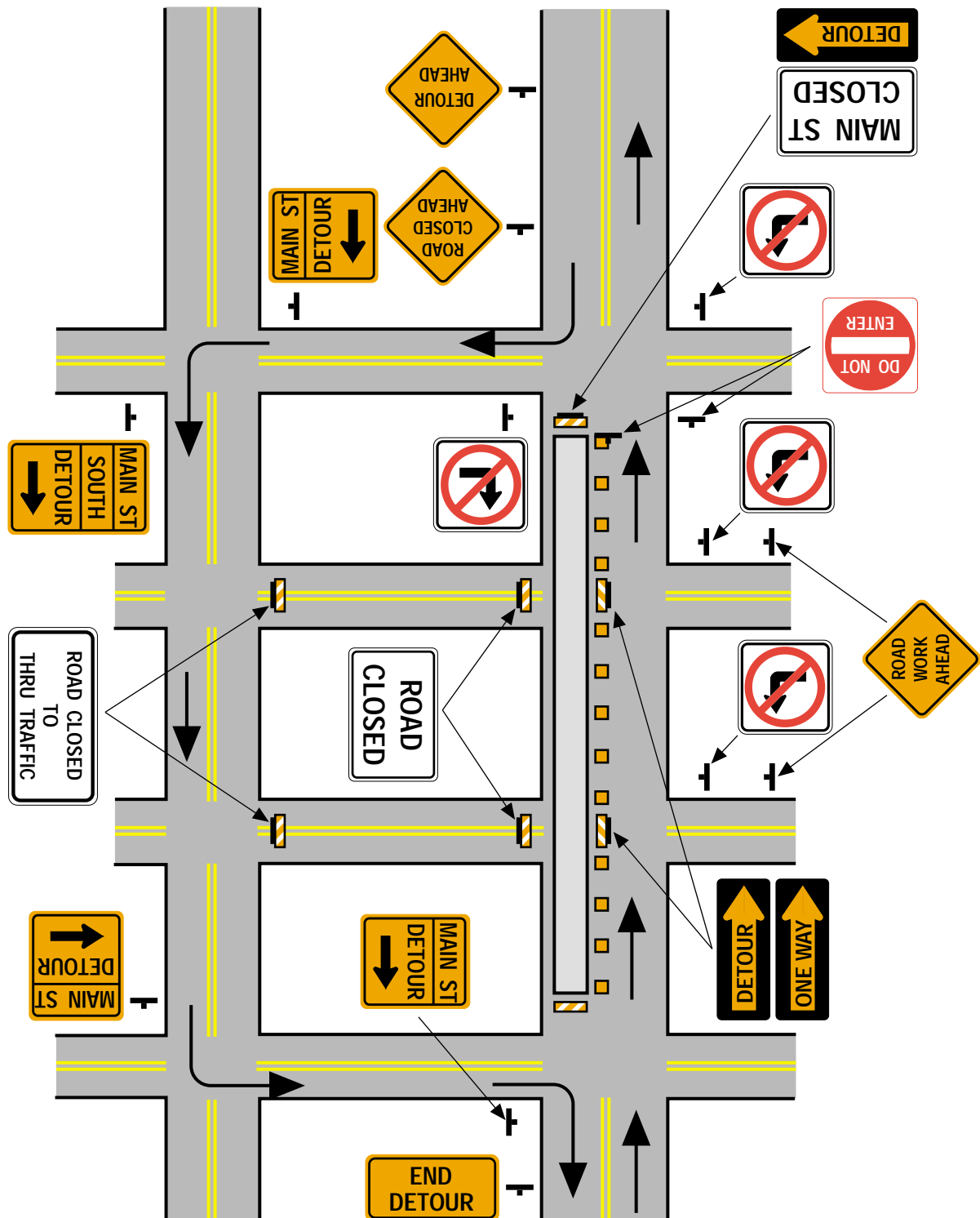
Typical Application 5-18 Lane Closure on Minor Street



Detour for One Travel Direction

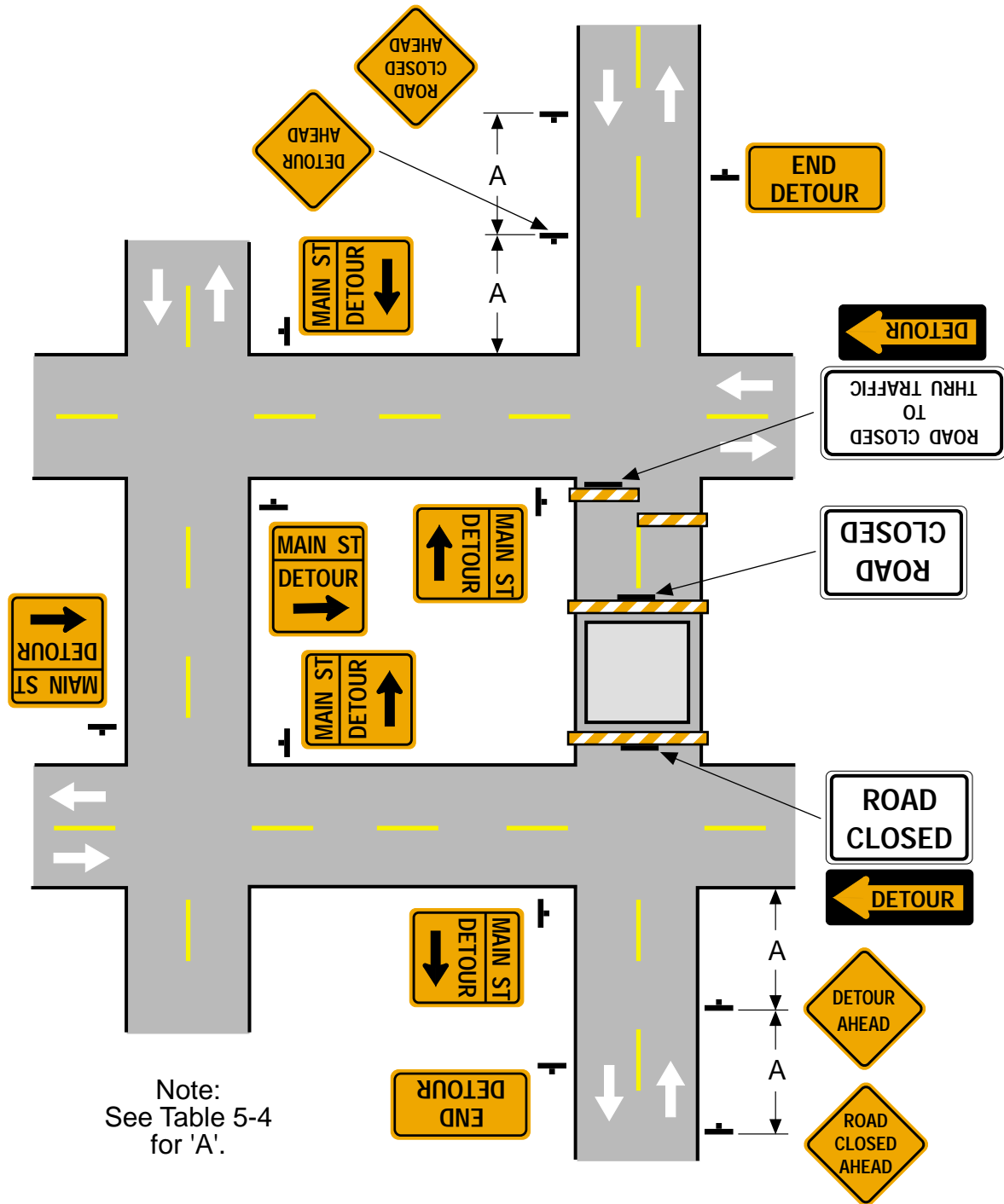
1. A STREET CLOSED plate may be used in place of ROAD CLOSED.
2. The use of a street name sign mounted with the DETOUR sign is optional. When used, the street name plate is placed above the DETOUR sign. The plate may have either a white-on-green or a black-on-orange legend.
3. Additional DO NOT ENTER signs may be desirable at intersections with intervening streets.
4. Warning lights may be used on Type III barricades.
5. DETOUR signs may be located on the far side of intersections.
6. Reassurance DETOUR signs should be placed at 400 m + intervals and at major intersections.

Typical Application 5-19 Detour for One Travel Direction



Detour for Closed Street

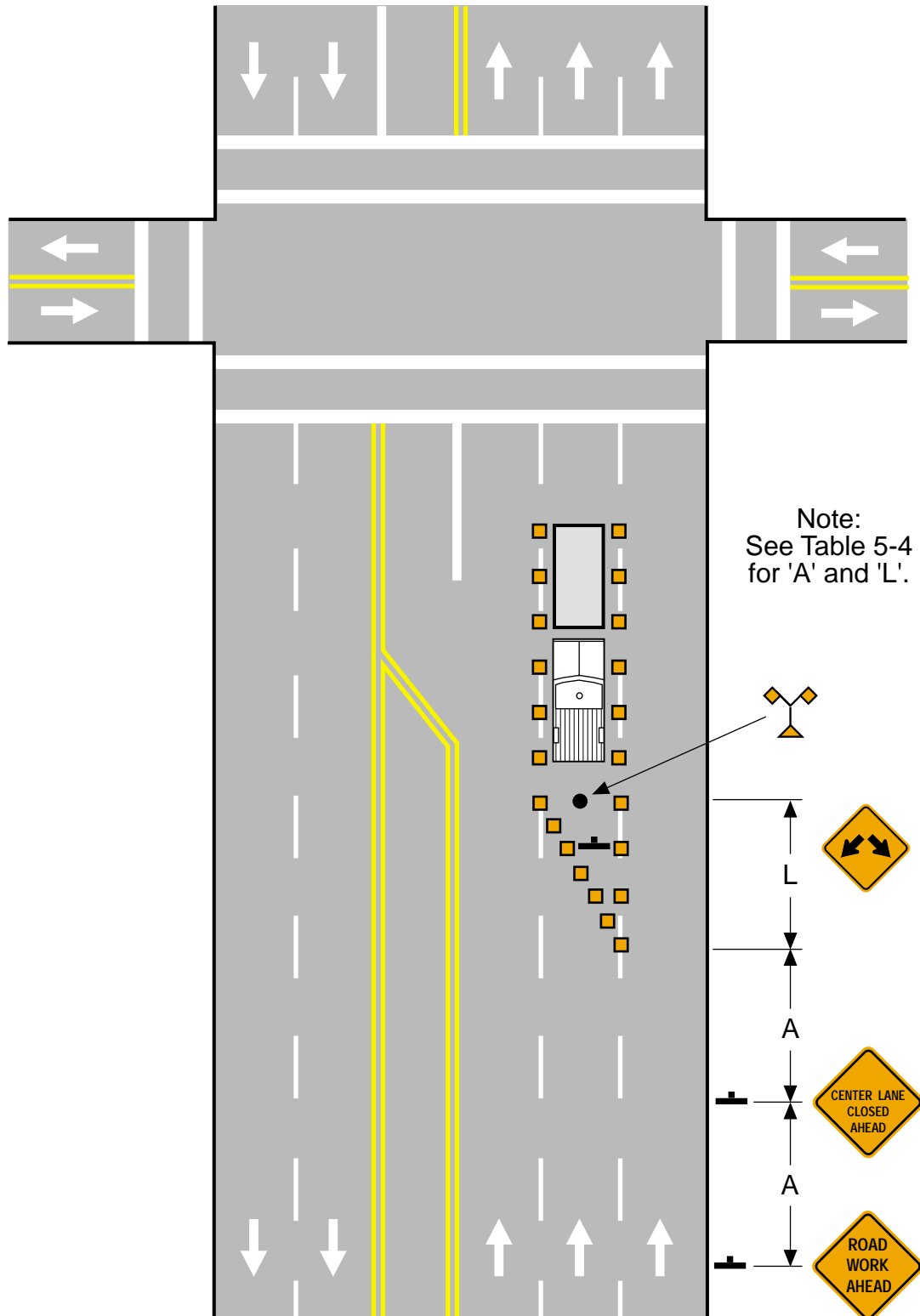
1. Display similar signs and devices for the opposite movement.
2. Use this plan for city streets and for county roads. See Figure TA5-9 for the procedure for detouring a numbered highway.
3. The use of a street name plate mounted with the DETOUR sign is optional. When used, the street name plate is placed above the DETOUR sign. The plate may have either a white-on-green or a black-on-orange legend.
4. A DETOUR sign with an advance turn arrow may be used in advance of a turn. On multilane streets, such signs should be used.
5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.
6. Warning lights may be used on Type III barricades.
7. DETOUR signs may be located on the far side of the intersections.

**Typical Application 5-20
Detour for Closed Street**

Lane Closure Near Side of Intersection

1. If the work space extends across the crosswalk, then close the crosswalk using the procedure and devices shown in Typical Application 5-29.
2. The merging taper may direct traffic into either the right or left lane, but not both. In this typical, a left taper should be used so that right-turn movements will not impede traffic.
3. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
4. Truck mounted FAS may be used to supplement this package.

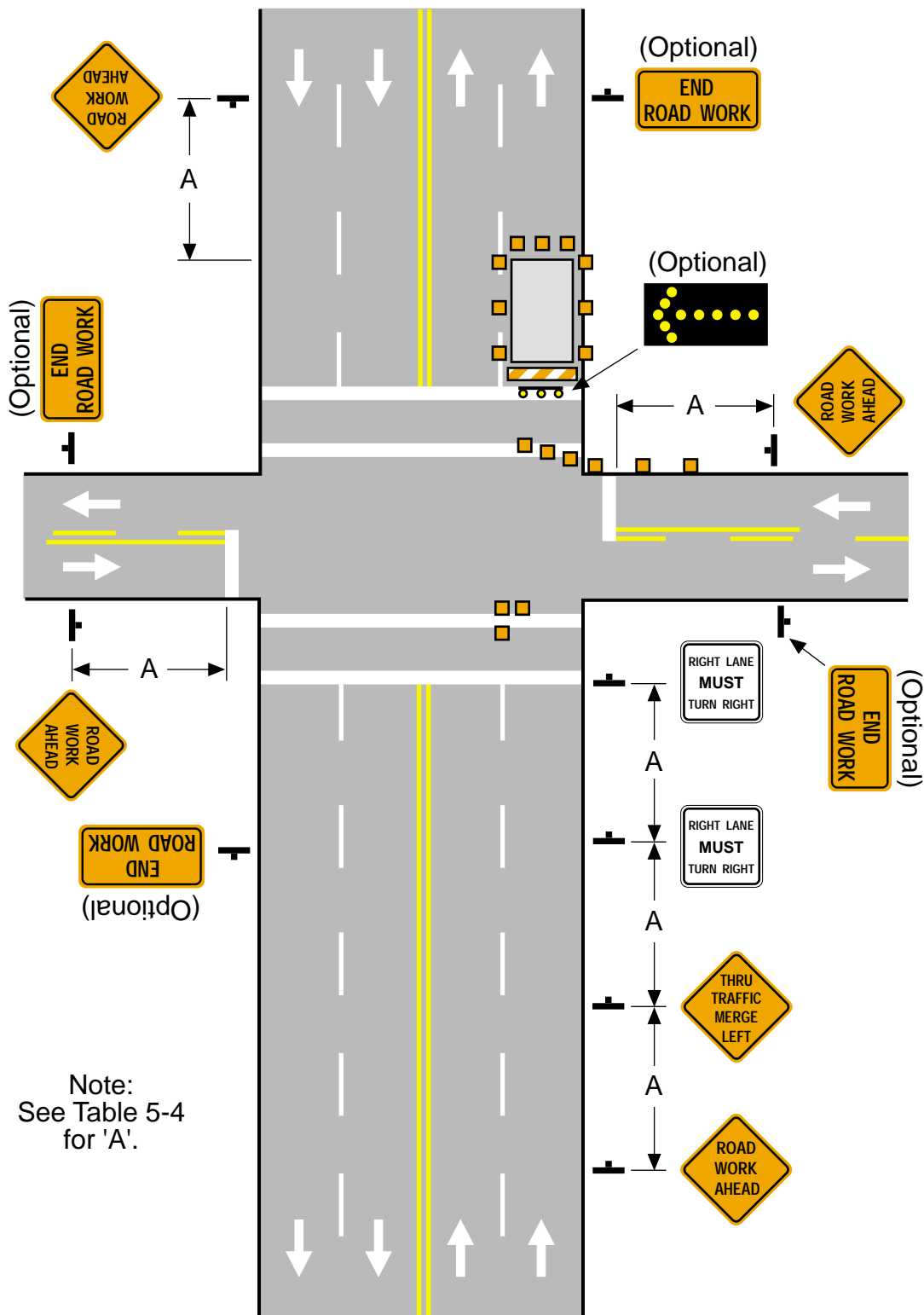
Typical Application 5-21 Lane Closure Near Side of Intersection



Right Lane Closure Far Side of Intersection

1. For intersection approaches reduced to a single lane, left-turning movements may be prohibited to maintain capacity for through traffic.
2. The standard procedure is to close on the near side of the intersection any lane that is not carried through the intersection. However, when this results in the closing of a right lane having significant right-turning movements, then the right lane may be restricted to right turns only, as shown. This procedure increases the through capacity by eliminating right turns from the open through lane.
3. Where the turning radius is large, it may be possible to create a right turn island using channelizing devices, as shown. This procedure reinforces the nature of the temporary exclusive right-turn lane and enables a second RIGHT LANE MUST TURN RIGHT sign to be placed in the island.
4. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in Typical Application 5-29.
5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.
6. Optional treatment see Typical Application 5-23.

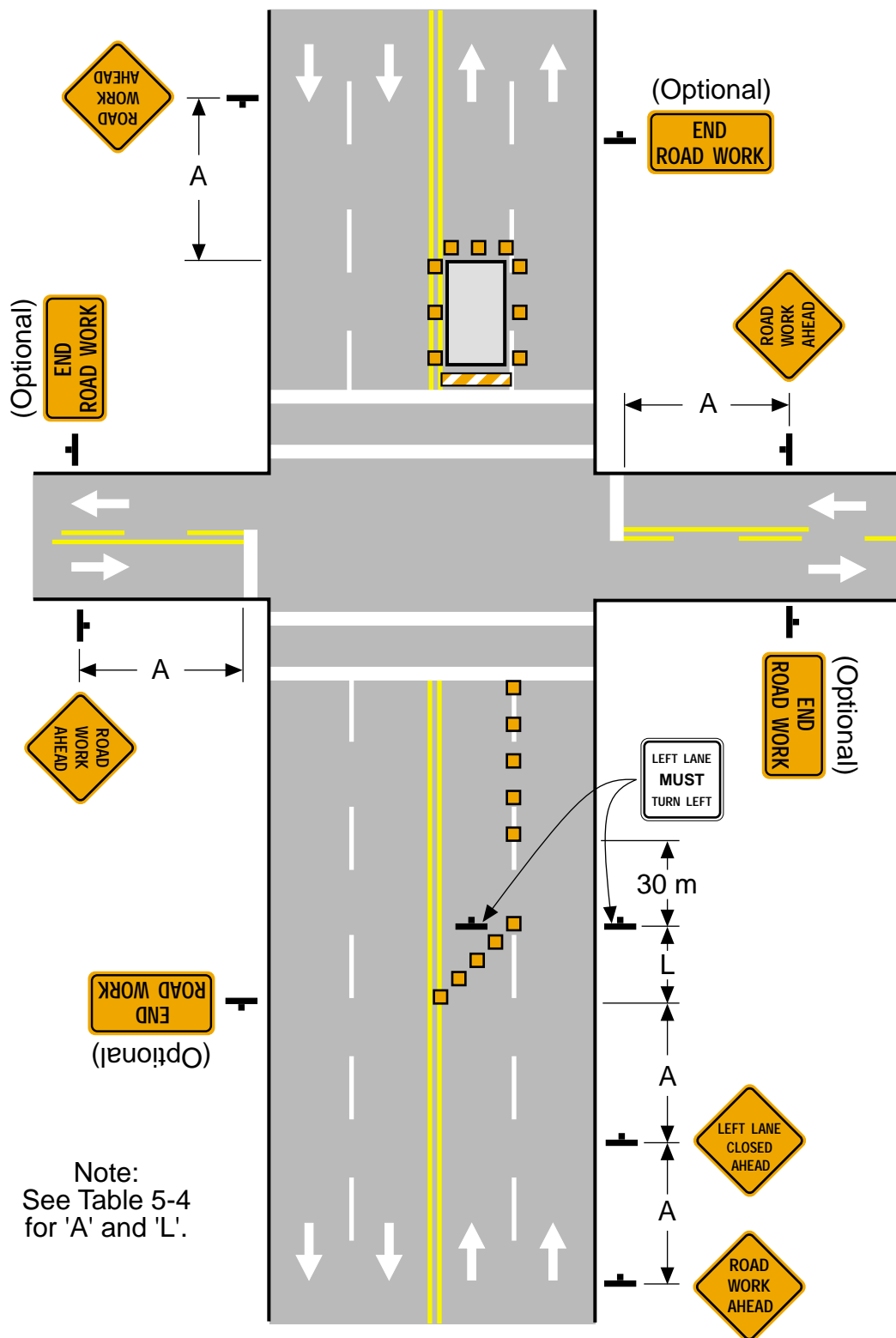
Typical Application 5-22 Right Lane Closure Far Side of Intersection



Left Lane Closure Far Side of Intersection

1. The standard procedure is to close, on the near side of the intersection, any lane that is not carried through the intersection. However, when this results in the closure of a left lane having significant left-turning movements, then the left lane may be converted to a turn bay for left turns only, as shown. By first closing off the left lane and then reopening it as a turn bay, an island is created with channelizing devices that allow the LEFT LANE MUST TURN LEFT sign to be repeated on the left, adjacent to the lane that it controls.
2. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in Typical Application 5-29.
3. Care should be taken to warn drivers of vision obstructions for left-turning vehicles caused by equipment, material, and work operations in the work zone.
4. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.
5. Optional see Typical Application 5-22.

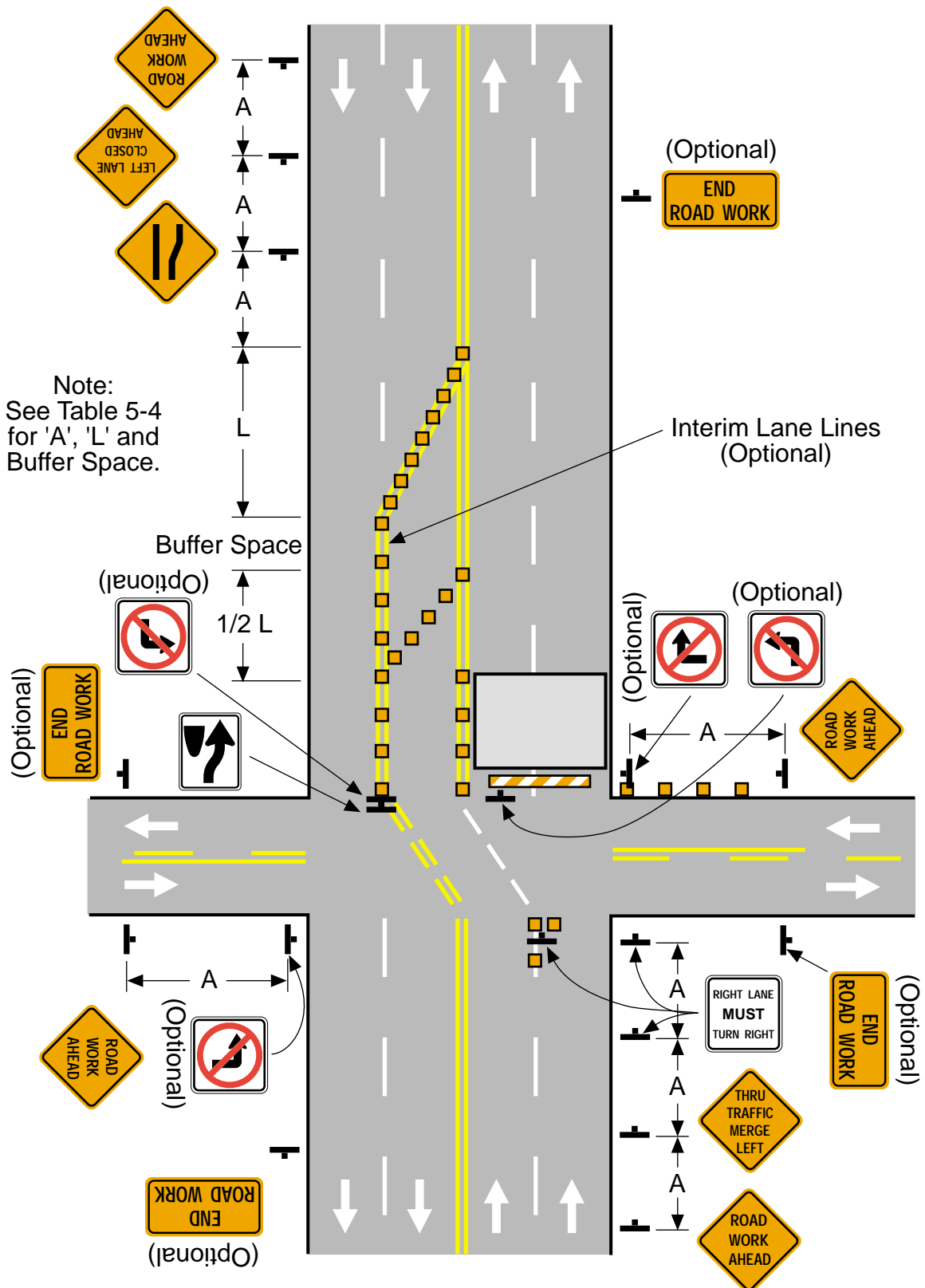
Typical Application 5-23 Left Lane Closure Far Side of Intersection



Half Road Closure Far Side of Intersection

1. For intersection approaches reduced to a single lane, left-turning movements may be prohibited to maintain capacity for through traffic.
2. The standard procedure is to close on the near side of the intersection any lane that is not carried through the intersection. Therefore, the right lane should be closed on the near-side approach. However, if there is a significant right-turning movement, then the right lane may be restricted to right turns only, as shown. This procedure increases the through capacity by eliminating right turns from the open through lane.
3. Where the turning radius is large, it may be possible to create a right-turn island using channelizing devices, as shown. This procedure reinforces the nature of the temporary exclusive right-turn lane and enables a second RIGHT LANE MUST TURN RIGHT sign to be placed in the island.
4. If the work space extends across a crosswalk, then close the crosswalk using the procedure and device shown in Typical Application 5-29.
5. A buffer space should be used between opposing directions of traffic as shown in this application.
6. There may be insufficient space to place the back-to-back KEEP RIGHT sign and NO LEFT TURN symbol signs at the end of the row of channelizing devices separating opposing traffic flows. In this situation, place the no left turn symbol sign on the right and omit the KEEP RIGHT sign.
7. Flashing warning lights and/or flags may be used to call attention to advanced warning signs.

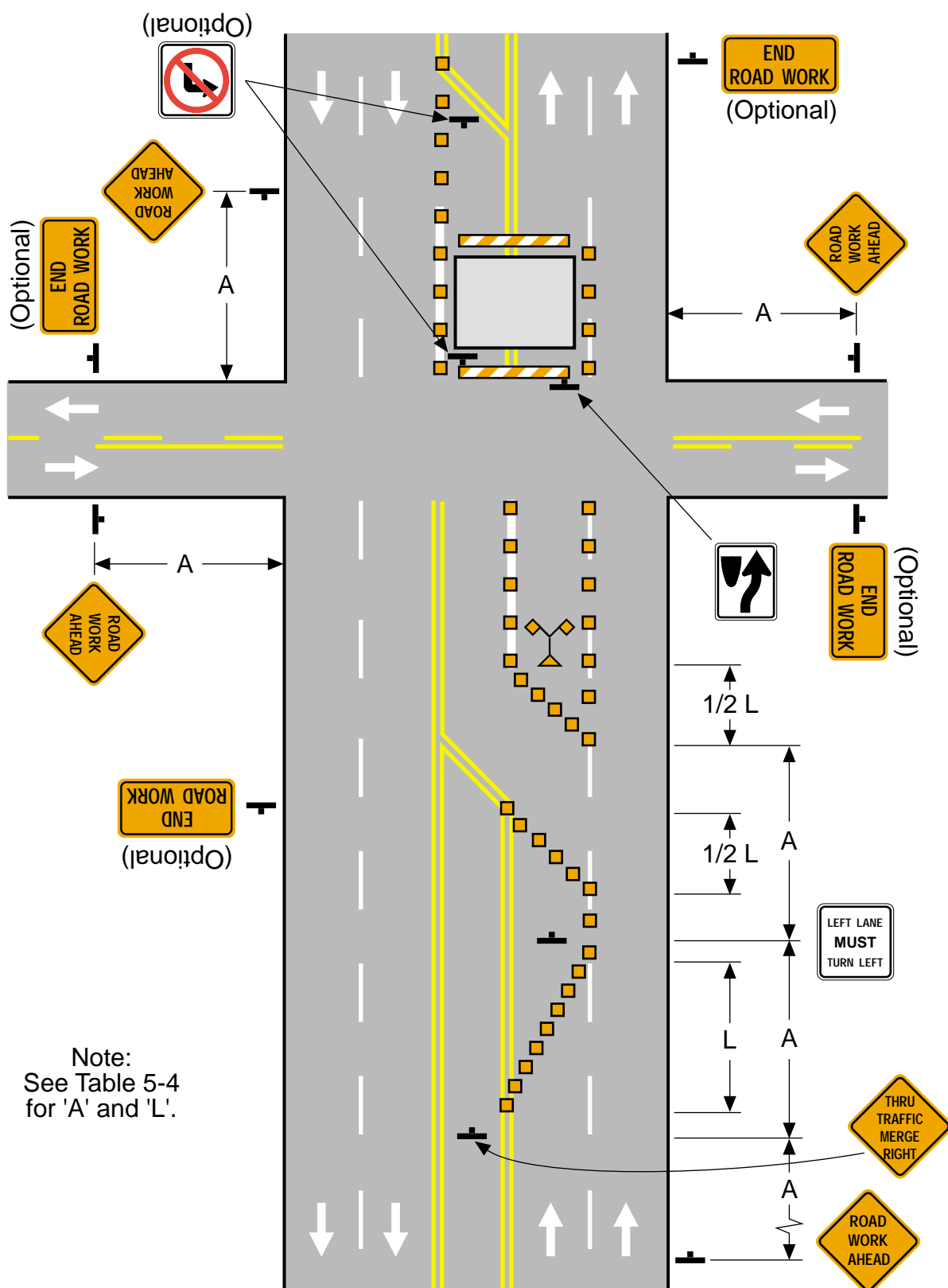
Typical Application 5-24 Half Road Closure Far Side of Intersection



Multiple Lane Closures at Intersection

1. The standard procedure is to close on the near side of the intersection any lane that is not carried through the intersection. Therefore, the left through lane is closed on the near-side approach. The LEFT LANE MUST TURN LEFT sign is placed in the median to deter through traffic from entering the left turn bay.
2. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in Typical Application 5-29.
3. If the left-turning movement that normally uses the closed turn bay is small and/or the gaps in opposing traffic are frequent, left turns need not be prohibited on that approach.
4. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

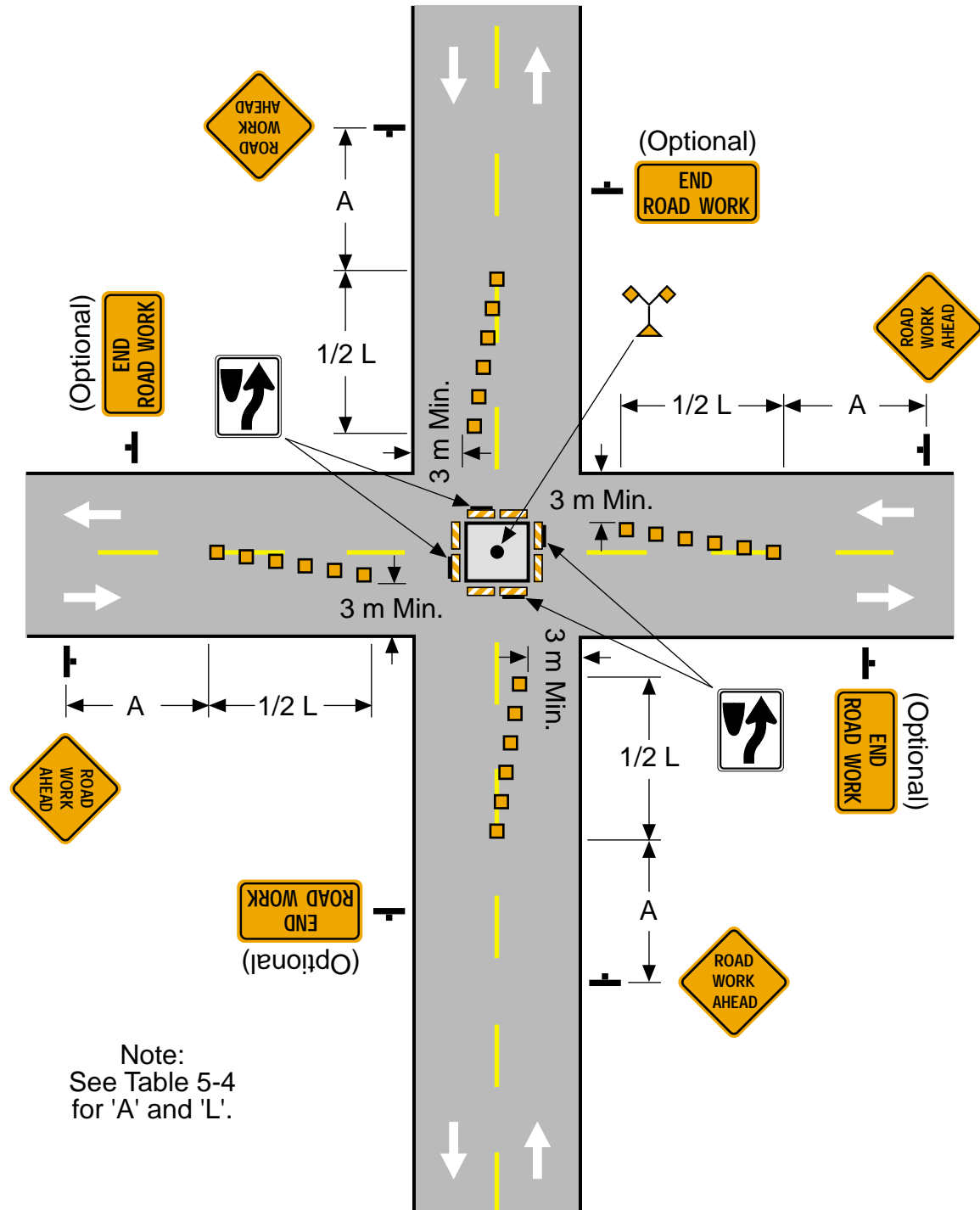
Typical Application 5-25 Multiple Lane Closures at Intersection



Closure in Center of Intersection

1. Prohibit left turns as required by traffic conditions. Unless the streets are wide, it may be physically impossible to turn left, especially for large vehicles.
2. A minimum of six channelizing devices shall be used for each taper.
3. For short-duration work operations, on low speed streets, the channelizing devices may be eliminated if a flashing or revolving yellow light is displayed in the work space.
4. A high-level flag tree should be placed in the work space if there is sufficient room.
5. Flashing warning lights and/or flags may be used to call attention to advanced warning signs.

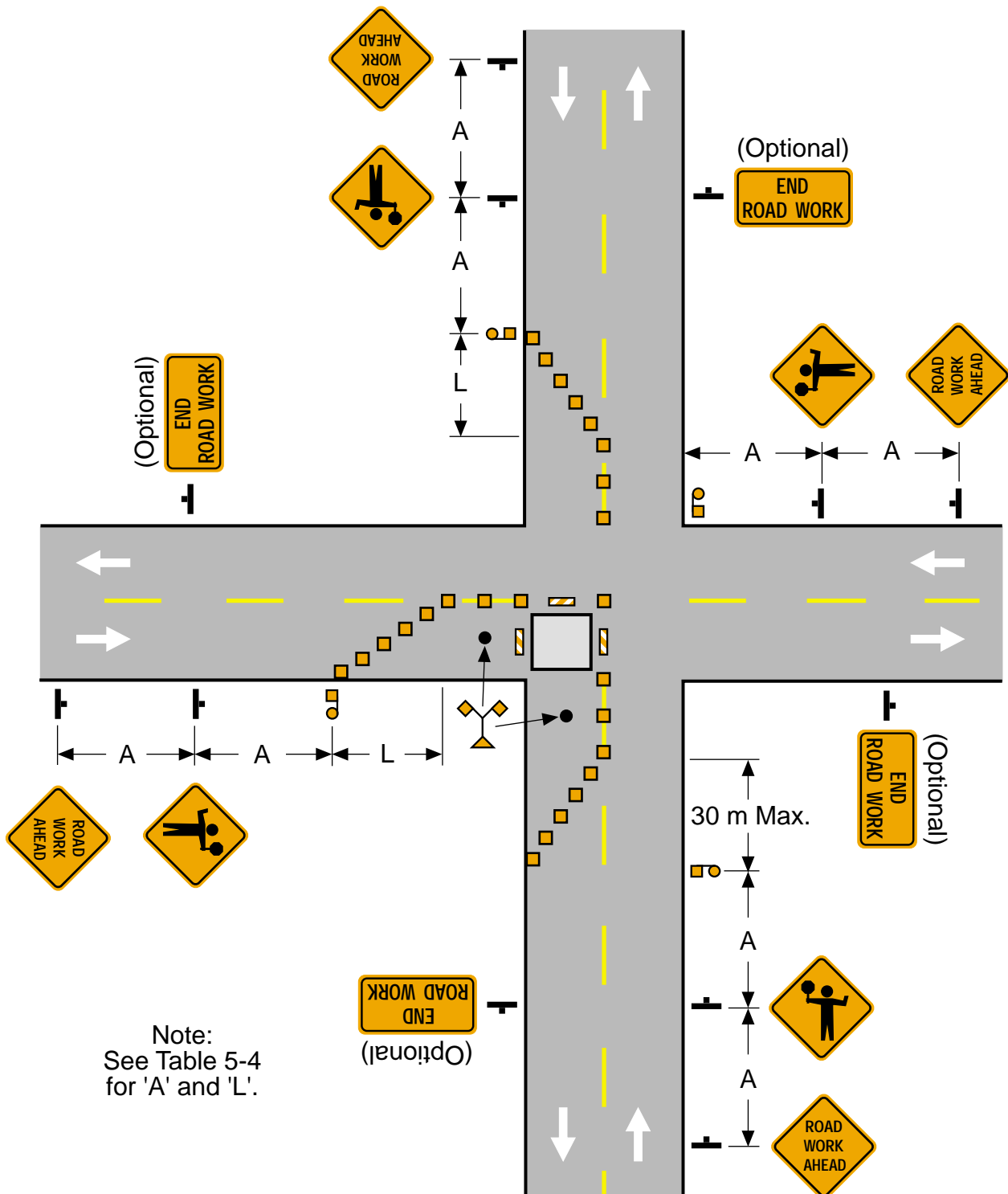
Typical Application 5-26 Closure in Center of Intersection



Closure at Side of Intersection

1. For low traffic volumes and intersecting two-lane streets, one flagger positioned in the center of the intersection may suffice.
2. For high traffic volumes or when a four-lane street is involved, additional flaggers or law enforcement personnel should be considered.
3. A ONE-LANE ROAD AHEAD sign may also be necessary to provide adequate advance warning.
4. The situation depicted can be simplified by closing one or more of the intersection approaches. If this cannot be done, and/or when capacity is a problem, consideration should be given to diverting through traffic to other roads or streets.
5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

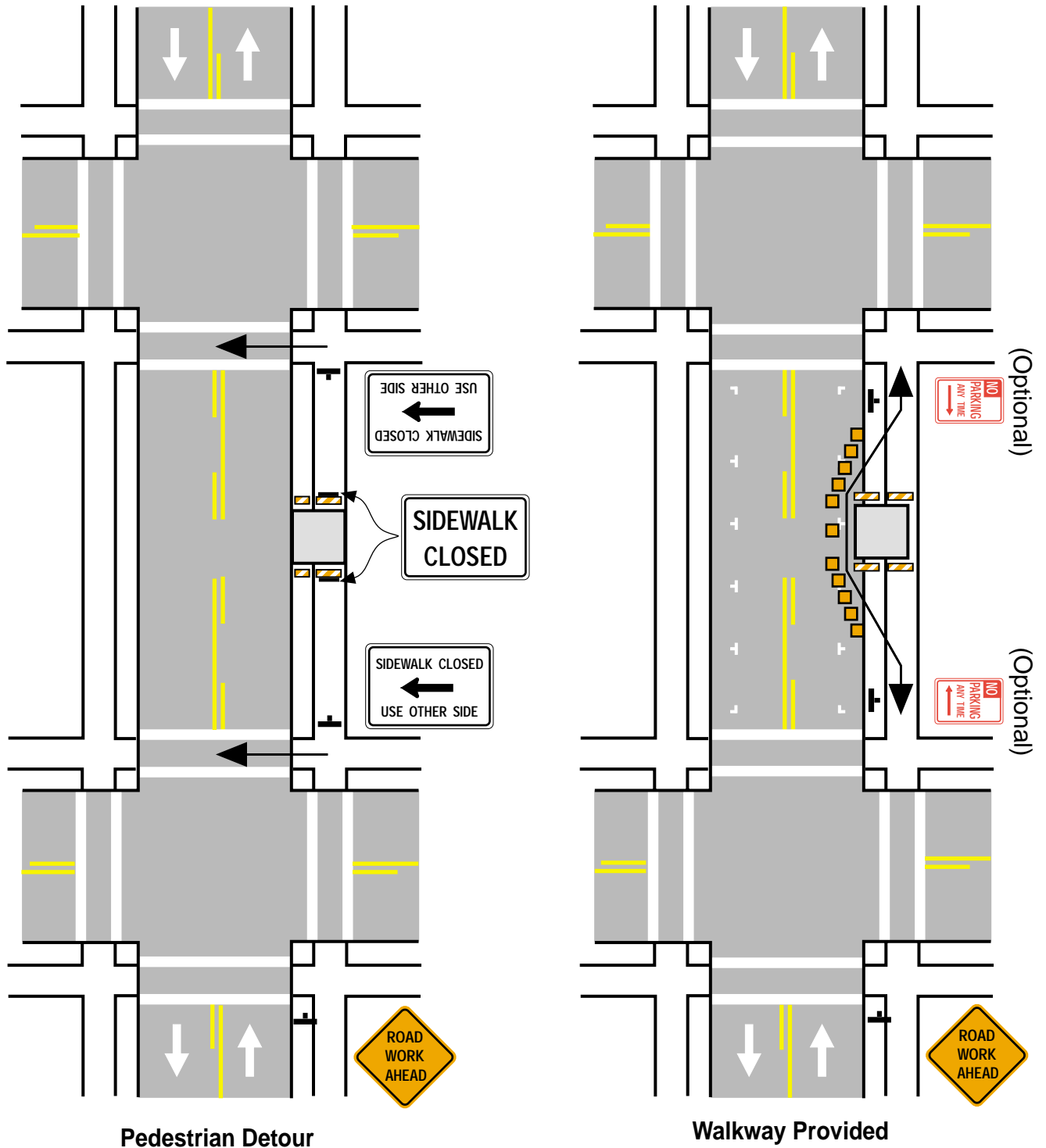
Typical Application 5-27 Closure at Side of Intersection



Sidewalk Closures and Bypass Walkway

1. Additional advance warning may be necessary.
2. Only the traffic control devices controlling pedestrian flows are shown. Other devices may be needed to control traffic on the streets. Use lane closure signing or ROAD NARROWS signs, as needed.
3. Street lighting should be considered.
4. For nighttime closures, Type A flashing warning lights may be used on barricades supporting signs and closing walkways. Type C steady-burn lights may be used on channelizing devices separating the temporary walkway from vehicular traffic.
5. Where high speeds may be anticipated, use a barrier to separate the temporary walkway from vehicular traffic.
6. Signs may be placed along a temporary walkway to guide or direct pedestrians. Examples include KEEP RIGHT and KEEP LEFT signs.

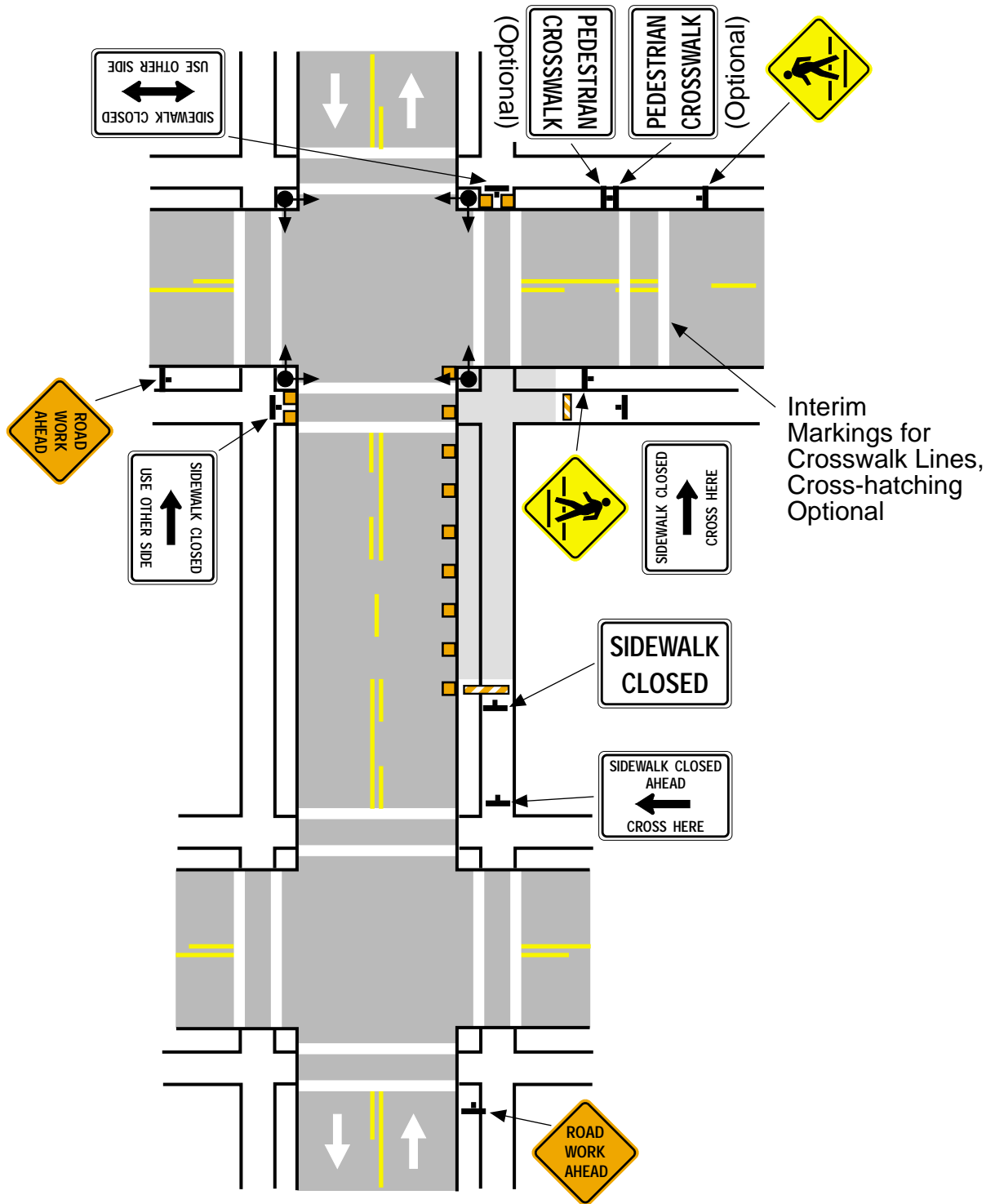
Typical Application 5-28 Sidewalk Closures and Bypass Walkway



Crosswalk Closures and Pedestrian Detours

1. Only the traffic control devices controlling pedestrian flows are shown. Other devices may be needed to control traffic on the streets. Use lane closure signing or ROAD NARROWS signs, as needed.
2. Street lighting should be considered.
3. For nighttime closures, Type A flashing warning lights may be used on barricades supporting signs and closing walkways. Use Type C steady-burn lights on channelizing devices separating the work space from vehicular traffic.
4. Pedestrian traffic signal displays controlling closed crosswalks should be covered or deactivated.
5. Parking should be prohibited in advance of midblock crosswalks.
6. Midblock crosswalks should be avoided when possible.

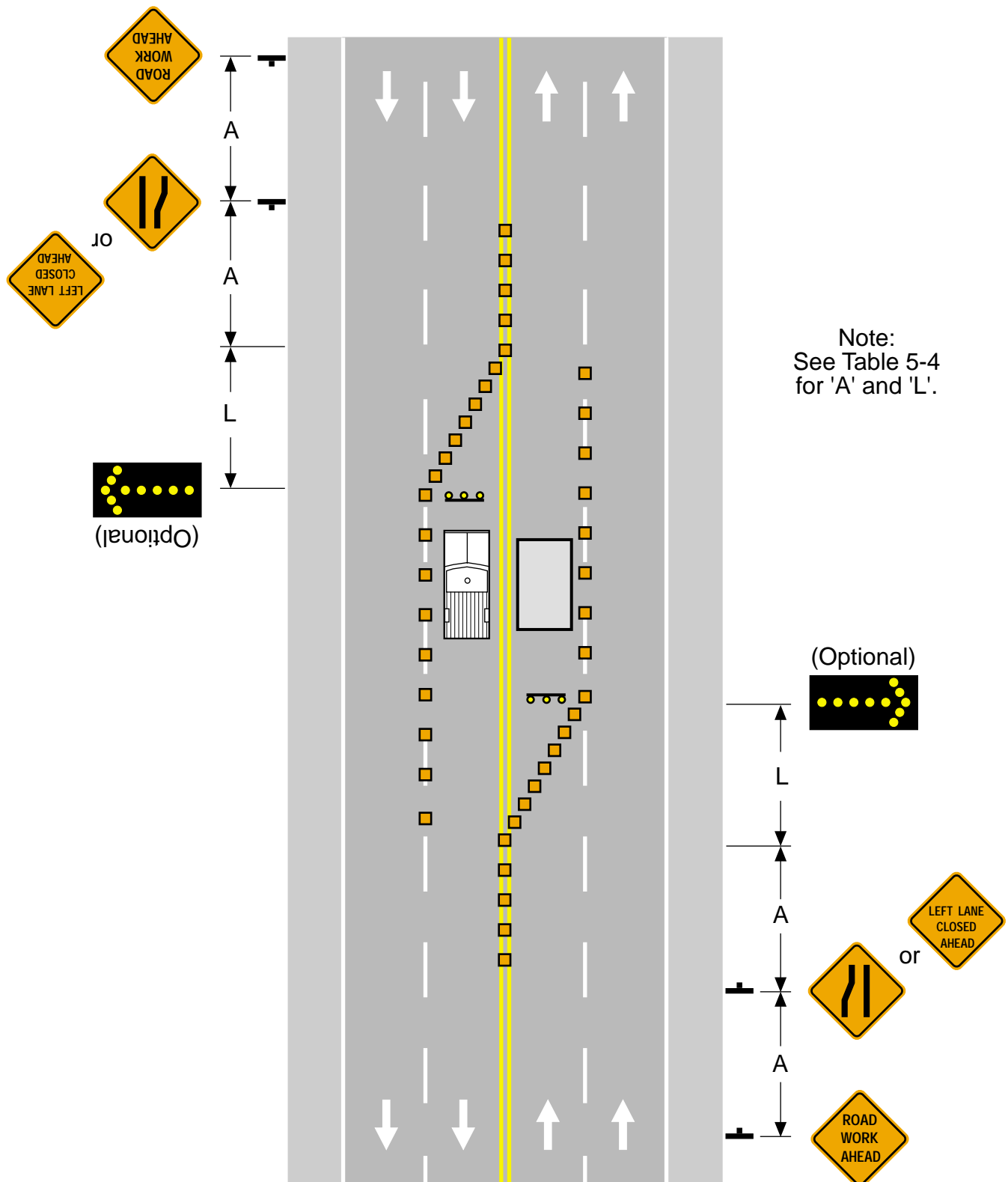
Typical Application 5-29 Crosswalk Closures and Pedestrian Detours



Interior Lane Closure on Multilane Street

1. The closure of the adjacent interior lane in the opposing direction may not be necessary, depending upon the activity being performed and the work space needed for the operation.
2. Additional advance warning may be necessary.
3. This procedure applies to low-speed, low-volume urban streets.

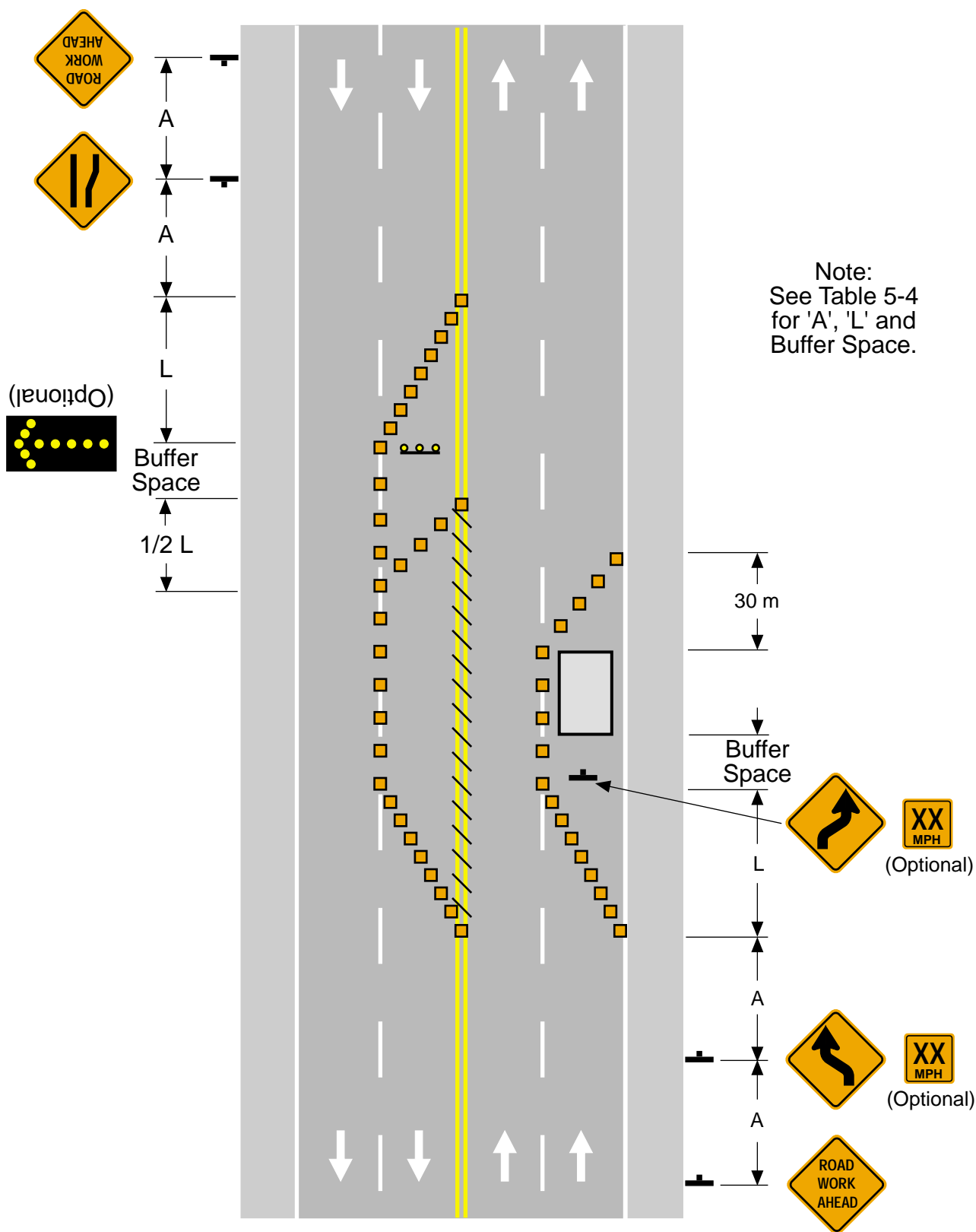
Typical Application 5-30 Interior Lane Closure on Multilane Street



Lane Closure on Streets with Uneven Directional Volumes

1. The illustrated procedure would be used only when the traffic volume is such that two lanes of traffic must be maintained in the direction of travel for which one lane is closed. The procedure may be used during a peak period of traffic and then changed to provide two lanes in the other direction for the other peak.
2. The traffic control devices shown are appropriate for an urban street. Additional advance warning may be necessary.
3. A buffer space should be used in the activity area and to separate opposing traffic.
4. Conflicting pavement markings should be removed for long-term projects. (See Section 5-06.3.) For shorter-term projects when this is not practicable, the channelizing devices in the area of conflict should be placed at a maximum spacing of 3 meters. Interim markings should be installed where needed.
5. For higher speeds, add a LEFT LANE CLOSED [distance] sign for traffic approaching the lane closure, as shown in Typical Application 5-32.
6. If the lane shift is short and has sharp curves (50 km/h or less), Reverse Turn signs should be used.
7. Where the shifted section is long, use a Reverse Curve sign to show the initial shift and a second one to show the return to the normal alignment. If the shift involves a short runaround, a symbol showing back-to-back reverse curves may be used. As an alternative side-by-side arrows may be used displaying one arrow for each lane. A supplementary plate stating ALL LANES THRU may be used to emphasize the point that no lanes are closed.

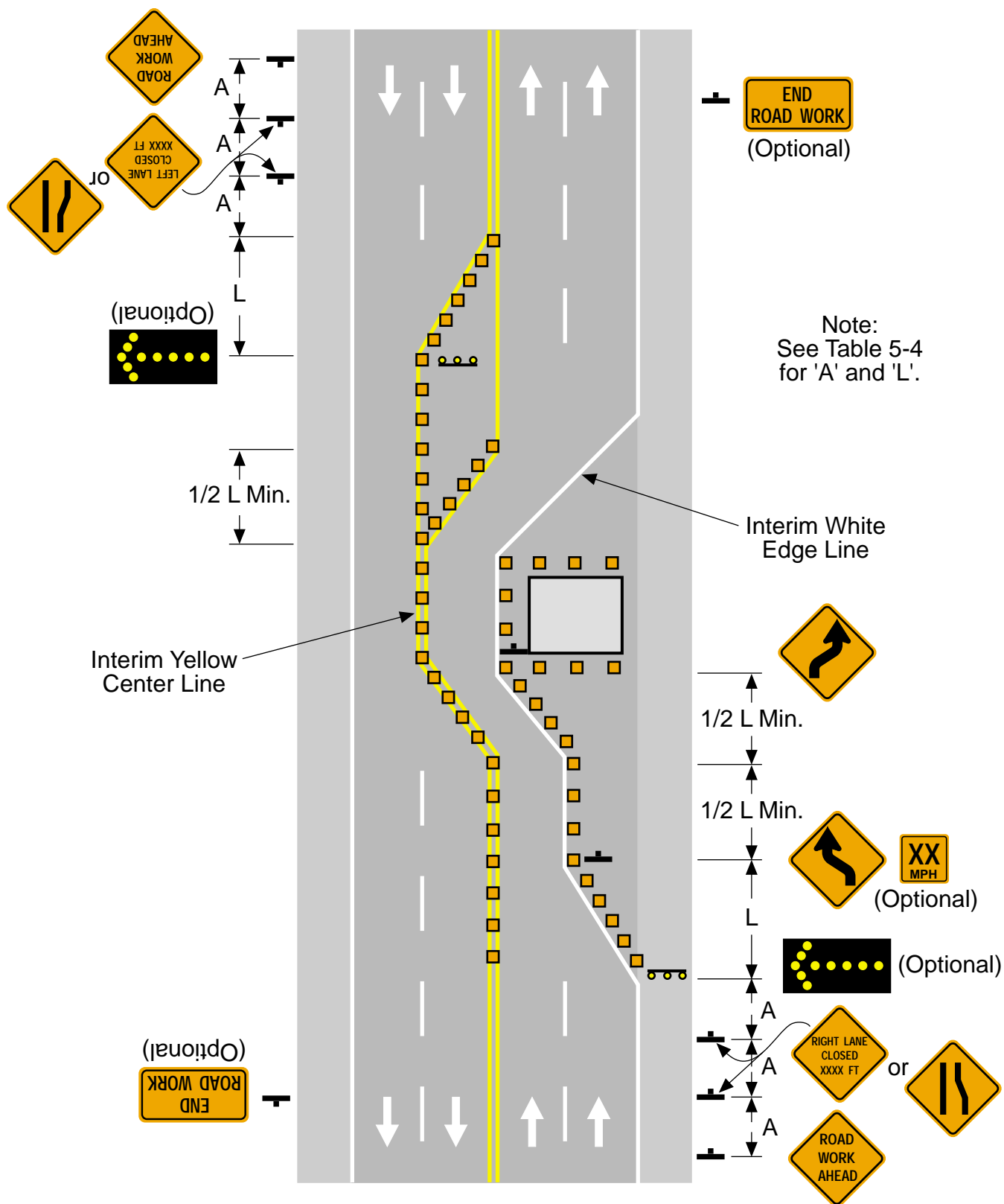
Typical Application 5-31 Lane Closure on Streets with Uneven Directional Volumes



Half Road Closure on Multilane High Speed Highways

1. The traffic control devices shown are appropriate for a high speed highway.
2. Pavement markings no longer applicable shall be removed or obliterated as soon as practicable. Interim markings shall be used as necessary.
3. Warning lights may be used to mark channelizing devices at night as needed.
4. For intermediate-term situations, when it is not feasible to remove and restore pavement markings, the channelization must be made dominant by using a very close device spacing. This is especially important in locations of conflicting information, such as where traffic is directed over a double yellow centerline. In such locations a maximum channelizing device spacing of 3 meters is recommended.

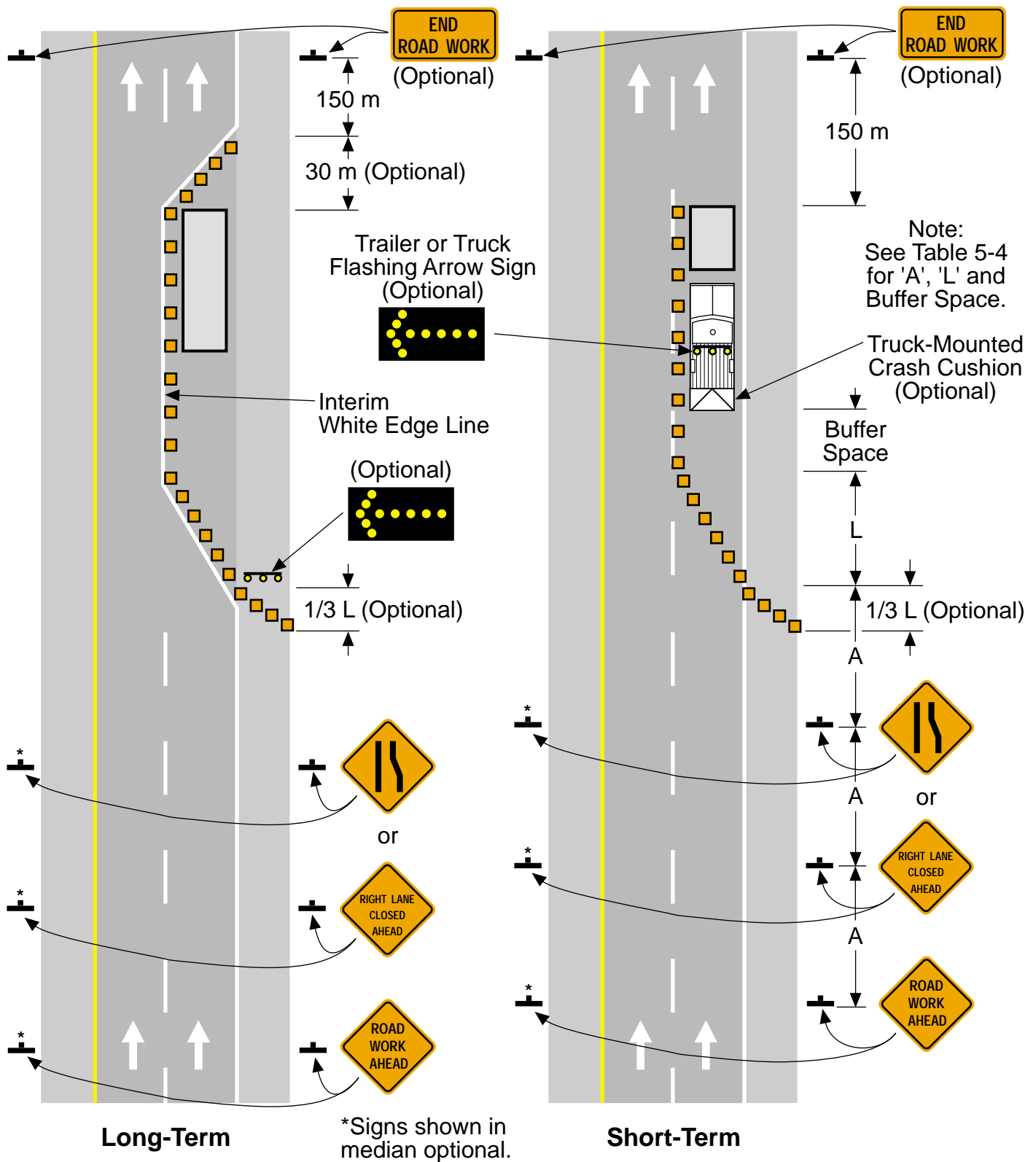
Typical Application 5-32 Half Road Closure on Multilane High Speed Highways



Lane Closure on Divided Highway

1. This procedure also applies when work is being performed in the lane adjacent to the median on a divided highway. Under these conditions, LEFT LANE CLOSED signs and the corresponding Lane Reduction symbol signs shall be used.
2. When a side road intersects the highway within the temporary traffic control zone, additional traffic control devices shall be erected, as needed.
3. Longitudinal dimensions may be adjusted slightly to fit field conditions.
4. All vehicles, equipment, workers, and their activities should be restricted to one side of the pavement.

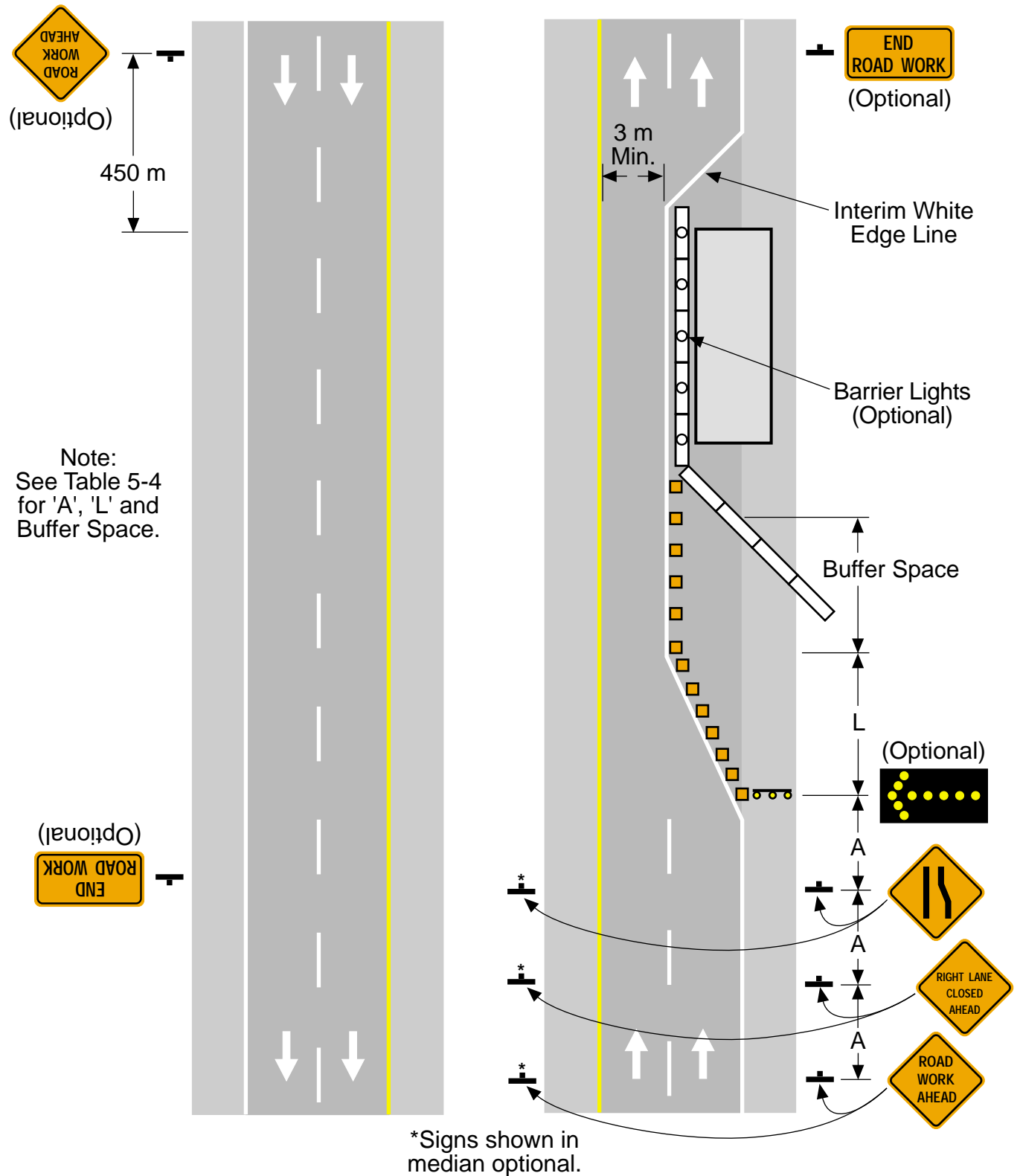
Typical Application 5-33 Lane Closure on Divided Highway



Lane Closure with Barrier

1. Additional advance warning may be necessary.
2. The use of a barrier should be based on the need determined by an engineering analysis.
3. The layout of the barrier should prevent vehicles from impacting the ends of the barrier. To accomplish this, the taper and end should be treated as given in chapter 9 of the ASSHTO Roadside Design Guide (RDG) or the Caltrans Standard Plans. Example treatments are connecting to an existing barrier, attaching a crashworthy terminal such as a crash cushion, or flaring away to the edge of the clear zone.
4. An interim white edge line should be installed from the start of the taper to a point beyond the work zone, rejoining the permanent edge line.
5. The barrier shall not be placed along the merging taper. The lane shall first be closed using channelizing devices and pavement markings. The barrier is then placed on a flare beginning beyond the downstream end of the merging taper.
6. Refer to Caltrans Standard Plans for barriers.

Typical Application 5-34 Lane Closure with Barrier



Mobile Operation on Multilane Road

1. Vehicles used for these operations should be made highly visible with appropriate equipment, such as flashing lights, rotating beacons, flags, signs, or flashing arrow signs (FAS).
2. Protection vehicle #1 should be equipped with an FAS. An appropriate lane closure sign should be placed on protection vehicle #1 so as not to obscure the FAS.
3. Protection vehicle #2 should be equipped with an FAS and truck-mounted crash cushion.
4. Protection vehicle #1 should travel at a varying distance from the work operation so as to provide adequate sight distance for traffic approaching from the rear.
5. When adequate shoulder width is not available, protection vehicle #1 should be eliminated.
6. On high-speed roadways, a third protection vehicle should be used; vehicle #1 on the shoulder (if possible), vehicle #2 in the closed lane, and vehicle #3 in the closed lane.
7. Flashing arrow signs shall be, as a minimum, Type B, 1800 by 900 mm (Figure 5-9, Section 5-05.4).
8. Work should normally be done during off-peak hours.

Typical Application 5-35 Mobile Operation on Multilane Road

